

*Site Investigation and
Remediation Report for
the North Parcel at the
Airport/Klondike Area*

Pratt & Whitney East Hartford, Connecticut

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July 28, 2000

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Comm. No. 88UT015.001

**SITE INVESTIGATION
AND
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PRATT & WHITNEY
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VOLUME II

UNIT SPECIFIC TECHNICAL MEMORANDA

Unit-Specific Technical Memoranda Introduction

North Airport:

Rentschler Airport Runway Area

Former Army Barracks Septic Systems

Silver Lane Pickle Company

North Klondike:

Undeveloped Land Area – Outside Storage Area

Undeveloped Land Area - Soil Pile



ACRONYMS

AC	Alternating Current
BZ	Benzene
CAS	Current Assessment Summary
CBZ	Chlorobenzene
CGS	Connecticut General Statutes
DC	Direct Current
DEP	Connecticut Department of Environmental Protection
DEC	Direct Exposure Criteria
DOT	Department of Transportation
DPH	Connecticut Department of Public Health and Addiction Services
EBZ	Ethylbenzene
EDR	Environmental Data Resources, Inc.
ELUR	Environmental Land Use Restriction
EM	Electromagnetic Terrain Conductivity
EPA	United States Environmental Protection Agency
F	Fahrenheit
FID	Flame-Ionization Detector
F&O	Fuss & O'Neill, Inc.
GBPMC	GB Pollutant Mobility Criteria
GC	Gas Chromatograph
gpm	gallons per minute
GPR	Ground Penetrating Radar
H&A	Haley & Aldrich, Inc.
IDEC	Industrial/Commercial Direct Exposure Criteria
LEA	Loureiro Engineering Associates, Inc.
LEA IMS	LEA Information Management System
MDC	Metropolitan District Commission
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
mhz	Megahertz
ml	milliliter
MOU	Memorandum of Understanding
MSL	Mean Sea Level
NGVD	National Geodetic Vertical Datum
NTU	Nephelometric Turbidity Units
PA	Public Act
P&W	Pratt & Whitney
PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethylene (Perchloroethylene)
PETG	Polyethylene Terephthalate Copolyester
PID	Photo-Ionization Detector
PMC	Pollutant Mobility Criteria
PVC	Polyvinyl Chloride



QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RCSA	Regulations of Connecticut State Agencies
RDEC	Residential Direct Exposure Criteria
RSRs	Remediation Standard Regulations
RVC	Residential Volatilization Criteria
SOP	Standard Operating Procedure
SPLP	Synthetic Precipitation Leaching Procedure
SVOCs	Semivolatile Organic Compounds
SWPC	Surface Water Protection Criteria
TCA	1,1,1-Trichloroethane
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TDEM	Time-Domain Electromagnetic Induction
TOC	Top Of Casing
TL	Toluene
TOR	Top Of Riser
TPH	Total Petroleum Hydrocarbons
U.S.	United States
USGS	United States Geological Survey
USTM	Unit-Specific Technical Memoranda
USTs	Underground Storage Tanks
UTC	United Technologies Corporation
UTRC	United Technologies Research Center
VCAP	Voluntary Corrective Action Program
VOCs	Volatile Organic Compounds
VPSA	Virgin Products Storage Area
VTOL	vertical takeoff or landing
µg/kg	micrograms per kilogram
µg/l	micrograms per liter
XYL	Xylenes

1. INTRODUCTION

Loureiro Engineering Associates, Inc. (LEA) was retained by Pratt & Whitney (P&W) to conduct a voluntary subsurface investigation and remediation at a portion of the P&W facility located at 400 Main Street (Main Street facility) in the Town of East Hartford, Connecticut. The portion of the Main Street facility addressed during this investigation and remediation is known as the Airport/Klondike Area.

On the northern end of the Airport/Klondike Area is a 75-acre portion (i.e., the Stadium Parcel) that has been offered to the State of Connecticut for the development of a football stadium. This Stadium Parcel is located on the northern end of the Airport/Klondike Area in an area that will be referred to as the North Parcel. This North Parcel includes the Stadium Parcel and environmental units that are immediately adjacent to the Stadium Parcel. To document the investigation and remediation activities that have occurred on, or relate to, the North Parcel, United Technologies Corporation (UTC) has retained LEA to prepare a stand-alone report that addresses the North Parcel.

The subsurface investigation and remediation at the Airport/Klondike Area was undertaken on a voluntary basis pursuant to Section 22a-133x(b) of the Connecticut General Statutes (CGS). Section 22a-133x of the CGS was codified and was formerly known as Section 3 of Public Act (PA) 95-183. The activities at the Main Street facility are also subject to the Voluntary Corrective Action Program (VCAP). On July 17, 1996, P&W and the United States Environmental Protection Agency, Region 1 (EPA-New England) signed a Memorandum of Understanding (MOU) that outlines the principle components of the VCAP. P&W's principal objective, as discussed in the MOU, is to have initiated stabilization activities at the Main Street facility on or before December 31, 2000.

This report includes background documentation of the site characterization investigations that have been performed to characterize the nature and delineate the extent of contamination identified in the Airport/Klondike Area, documentation of the remediation activities that have been conducted, and relevant information necessary to verify that the investigation and remediation have been performed in accordance with prevailing standards and guidelines. It must be noted that this report is current for all investigation and remediation activities that have been conducted through July 1, 2000.



1.1 Purpose and Scope

This report provides documentation of the subsurface investigations that have been performed by LEA at the North Parcel and summarizes the results of these investigations. The data collected during the investigations have been used to characterize the North Parcel with respect to releases of oils or hazardous materials to soil and groundwater, to delineate the extent of contamination detected on or emanating from the North Parcel, and to determine if remedial activity was required to address any identified contamination. The subsurface investigations were conducted in a manner that supported the evaluation of the need for remediation in accordance with the requirements of the Connecticut Remediation Standard Regulations (RSRs) (Sections 22a-133k-1 through 22a-133k-3) of the Regulations of Connecticut State Agencies (RCSA). The specific intent of the remedial activities was to conduct the activities in a manner that would render the North Parcel compliant with the RSRs. In general, the remedial activities were to remove all or portions of the areas with identified exceedances of soil criteria to satisfy the RSRs.

The subsurface investigation was designed to provide sufficient information to characterize the nature and delineate the extent of contamination detected in the Airport/Klondike Area including the North Parcel. To achieve the stated goal and objectives, the subsurface investigation was conceived to include both environmental setting and contaminant delineation investigations. The objective of the environmental setting activities was to develop a Site-wide understanding of environmental conditions in soils and groundwater, particularly in the context of how those conditions might affect the fate and transport of potential contaminants. The environmental setting investigations were also designed to characterize the unconsolidated materials in terms of physical characteristics to define the stratigraphy and soil properties of both the saturated and unsaturated zones across the Airport/Klondike Area. The data generated was compared against the applicable regulatory criteria established in the RSRs to evaluate compliance with those criteria. A complete discussion of the sampling methodology and sample selection criteria used in the investigation is presented in later sections of this report.

The objective of the contaminant delineation investigation was to define the nature, and delineate the extent of soil and groundwater contamination at the Airport/Klondike Area including the North Parcel. The contaminant delineation investigation was designed to include both initial and focused soil sampling activities and site-wide groundwater sampling activities. The initial activities were designed to evaluate larger portions of the Airport/Klondike Area and included soil vapor surveying and geophysical surveying consisting of both time-domain electromagnetic induction (TDEM) and magnetometry. The results of the initial activities were used to direct the placement of soil borings and test-pit excavations to be conducted in the focused soil sampling activities in select areas in the Airport/Klondike Area.

1.1.1 Report Organization

This report documents the investigation and remediation activities completed for the North Parcel between June 1996 and present, interprets the data collected, and provides conclusions derived from this data. This report presents our findings and conclusions resulting from our inquiry into the previous ownership and uses of the Parcel, and our review of practically reviewable, publicly available, and reasonably ascertainable standard environmental record sources, standard historical sources, and standard physical setting sources. The information contained within this report includes a detailed description of the North Parcel.

1.1.2 Main Document Sections and Appendices

In presenting the investigation and remediation activities completed for the North Parcel, section discussions are followed by supporting tables, figures, and drawings. The following is a general description of the contents of each of the following sections of the report.

- Section 2 includes a summary facility description and includes pertinent background information. In addition, it contains information regarding facility operations and former investigations conducted at the Airport/Klondike Area including the North Parcel.
- Section 3 describes the methodologies for the field investigation activities performed during the Airport/Klondike Area characterization, specifically those conducted for the North Parcel. These activities included the performance of soil vapor and geophysical surveys, soil boring installation, monitoring well installation, the performance of test-pit excavations, and soil and groundwater sampling.
- Section 4 describes the methodologies for the management, documentation, verification, and presentation of the data collected as part of the investigation and remediation activities. Section 4 also includes a discussion detailing the results of quality assurance/quality control (QA/QC) samples that were submitted to each laboratory providing analytical services as part of this project.
- Section 5 presents the results of the environmental setting investigations conducted at the Airport/Klondike Area including the North Parcel. In addition, it details the environmental setting of the Airport/Klondike Area and includes discussions of the site-specific geologic and hydrogeologic conditions encountered and of regional geologic and hydrogeologic conditions as derived from available published information.



- Section 6 presents an overview of the soil and groundwater analytical results obtained during the investigation and remediation for the North Parcel.
- Section 7 provides an overall evaluation of the soil and groundwater data against the applicable tabulated numeric criteria established pursuant to the RSRs for the North Parcel.
- Section 8 provides an overview of remedial activities performed in each area and the evaluation of the confirmatory sample data against the applicable tabulated numeric criteria established in the RSRs for the North Parcel.
- Section 9 presents a summary of the findings and conclusions resulting from the evaluation of the data obtained during the subsurface site investigations and remedial activities for the North Parcel.

1.1.3 Tables, Figures, and Drawings

To maintain the readability of this report and to prevent the numerous tables and figures from interfering with the flow of the text, all of the tables, figures, and drawings have been placed after the final text sections of the main body of the report. Table and figure groupings are marked with dividers so readers can easily refer to them when necessary. Supporting documents, including boring logs and well completion logs, are provided as appendices to the report.

1.1.4 Unit-Specific Technical Memoranda

Technical Memoranda that present the results of soil and groundwater sampling and analysis in the vicinity of specific environmental units that were investigated as part of the investigation activities have been prepared to aid in the identification and evaluation of sources or potential sources of contamination in the North Parcel portion at the Airport/Klondike Area of the P&W Main Street facility. These Unit-Specific Technical Memoranda (USTMs) include pertinent background information for each of the environmental units for which a subsurface investigation was conducted. Additional information concerning the USTM organization and conventions is included in a separate introduction for the USTMs.

As applicable, each USTM includes the rationale for conducting any investigation activities at that location, an outline of any investigation that was performed, analytical results from the investigation, and any conclusions based on the data collected. In cases where remediation activities were conducted, each USTM also includes the rationale for conducting any remediation activities at that location, an outline of any remediation activities that were performed, the analytical results upon completion of the remediation activities, and conclusions based on the data collected. The USTMs are current for all investigation and remediation activities that have been conducted through July 1, 2000.



2. BACKGROUND

The intent of this section is to provide the reader with an overview of the Airport/Klondike Area and the North Parcel background information. This section also includes some general information on the Main Street facility and the Airport/Klondike Area to provide a sense of perspective when considering the North Parcel relative to the whole of the Main Street facility and the Airport/Klondike Area.

2.1 Location and Description

The P&W Main Street facility is located on over 960 acres with over 6.5 million square feet of floor area for manufacturing, research, office space, and space for related activities and support services. The facility has been used for the manufacture of aircraft engines and aircraft engine components since December 1929. Operations at the facility include, or have included in the past, metal parts machining, vapor degreasing, chemical etching, cleaning, electroplating, painting, assembly and testing, and research operations.

To the east of the main factory complex of the Main Street facility lies the approximately 600-acre Airport/Klondike Area consisting of the Rentschler Airport and an area, known as the Klondike, formerly used for experimental test operations as well as ancillary support operations for the main factory complex. On the northern end of the Airport/Klondike Area is a 75-acre portion (i.e., the Stadium Parcel) that has been offered to the State of Connecticut for the development of a football stadium. This Stadium Parcel is located on the northern end of the Airport/Klondike Area within an area that will be referred to as the North Parcel. This North Parcel includes the Stadium Parcel and environmental units that are immediately adjacent to the Stadium Parcel. The North Parcel is an approximately 127-acre portion that is the Parcel as addressed in this report.

The entirety of the Main Street facility is bordered on the north by a residential neighborhood and Silver Lane, on the south by a residential neighborhood and Brewer Street, on the west by Main Street and a residential area, and on the east by a residential area and Penney High School. A site location map for the Main Street facility was prepared from portions of the Glastonbury, Hartford-North, Hartford-South, and the Manchester United States Geologic Survey (USGS) 7.5 minute topographic maps and is included as Figure 1. A site plan of the entire facility including the Airport/Klondike Area is provided as Figure 2. Figure 2 also indicates the North Parcel, which is the focus of this report, as well as the Stadium Parcel.

Willow Brook runs through the north end of the Main Street facility in an east to west direction toward the Connecticut River. The brook is dammed and ponded within the Main Street facility. The United Technologies Research Center (UTRC), through which a portion of Willow Brook passes, is located on the north central border of the Main Street facility, to the west of the North Parcel, and does not constitute part of the Main Street facility.

Overall, the Main Street facility has been divided into 26 study areas. Of these study areas, the 4 areas that encompass the Airport/Klondike Area include the North and South Airport Areas and the North and South Klondike Areas. For the North Parcel, portions of 2 of the study areas consisting of the North Airport Area and the North Klondike Area are included in the North Parcel. Within the portions of the 2 study areas present in the North Parcel, and addressed in this report, there are a total of 4 sub-areas. Within the 4 sub-areas, there are a total of 6 environmental units that are described in 5 USTMs. The layout of the North Parcel complete with the study areas and sub-areas is shown on Drawing 1.

2.2 Site History and Ownership

The majority of the property on which the Main Street facility is currently located was purchased by United Aircraft Corporation, now United Technologies Corporation, from American Sumatra Tobacco Company in 1930. At the time it was purchased, the eastern portion of the property, which subsequently became the Airport/Klondike Area, was a tobacco field. Over time, numerous additional parcels were purchased and included as part of the Main Street facility.

Rentschler Field was opened in 1931 and at that time it was an all-turf airfield. The all-turf airfield consisted of approximately 165 acres of land constructed to promote drainage and suitable for use in all weather conditions and seasons. During the initial operations, Rentschler Field had two hangars including a service hangar and an experimental hangar. Fueling, deicing and miscellaneous aircraft repair operations were conducted in the vicinity of the hangars. These hangars were located in the vicinity of the present Main Street facility.

Originally created as a test field, Rentschler Field was subsequently expanded into a service center for the overhaul and maintenance of P&W engines. The airfield served as a base for experimental flight tests of airplanes, engines, and propellers. The hangars associated with the airport were used to service company-owned and customer-owned airplanes. The airport was used for scheduled flights by American Airlines in 1939 and for the flight testing of the Vought Corsair.

Construction of an airport expansion began in 1939 and was completed in 1941. In 1941, the hangars were moved more than one-half mile from an area to the west of the runways, in the

approximate location of L and M Buildings within the main factory complex, to the northwest edge of the field at their present location. Coinciding with the airport expansion, the hangar size was doubled. At that time, the runways were paved and the runways extended to 3,500 feet for the north-south runway and 3,000 feet for the northeast-southwest runway. The expansion of the airport also included the construction of a control tower, the construction of an experimental laboratory, and offices. The majority of these construction activities were completed to the west and off the Airport/Klondike Area.

P&W's Airport Division cooperated in the war program by overhauling engines in service to the United States (U.S.) Armed Forces, the British Air Commission and other major airlines and companies engaged in the war effort. The airfield also became the operating base for certain U.S. Armed Forces, the British Air Commission, major airlines and companies engaged in the war effort. In support of the war effort, U.S. Army Air Forces pursuit groups, which provided fighter-plane protection for manufacturing plants in the greater Hartford area, were based at the airport. Between 1941 and 1945, the Main Street facility and the airport were leased by the U.S. government as part of this war effort.

In 1945, the airfield was modernized and expanded to include three asphalt runways, each a mile long, and a fully equipped, 57-foot control tower. Given the low elevation of the airport, fill was excavated from the Klondike Area and placed on the airport. This excavation accounts for some of the wetland areas in the undeveloped area along the east side of the North Klondike Area. During this period, the Tie-Down Area, located in the South Klondike Area, was used to secure aircraft close to the runways. The Tie-Down Area was also used for aircraft refueling from an aboveground storage tank. In 1947 the name of the airport was changed from Rentschler Field to Rentschler Airport.

Throughout the 1930's and part of the 1940's, the Klondike Area remained undeveloped. In the early 1950's, the North Klondike Area was developed to include the numerous buildings and test stands in association with various research operations. At approximately this same time, undeveloped parcels to the east and south of the developed portion of the North Klondike Area were purchased.

In the late 1950's, the South Klondike Area was developed to include a Hydrogen Gas Plant, the Cryogenics Building and the Fire Pump House. A firing range also existed in the South Klondike Area, although the exact times of construction and operation are unknown. A large portion of the Klondike Area, along the eastern most edge of the property, has been undeveloped throughout its history.



A new control tower, at the south end of Rentschler Airport, was built and occupied by May 1966. At that time, parking areas were enlarged to accommodate the expanding work force at the airport. Between 1965 and 1970 the South Klondike Area was expanded with storage areas, the Quonset Hut Storage Area, and the X-307 test stand. In 1967, new experimental test cells for the JT9D engine were constructed in the Klondike Area.

Rentschler Airport runways were lengthened in 1971. A microwave landing system was also installed in 1971 to improve night landings. With these improvements, Rentschler Airport became the second largest airport in Connecticut, smaller only than Bradley International Airport. Few major changes took place in the 1980's.

The majority of the Klondike Area remained active until the early 1980's when some test stands were dismantled and moved to other facilities off the Site. Through the late 1980's and early 1990's, the use of the Klondike Area was gradually diminished. The buildings in the Klondike Area were razed in 1993 with the exception of the generator/transformer room associated with the Fire Pump House in the South Klondike Area. The Airport was shut down in December 1994. Currently, the Airport/Klondike Area is no longer used for any production, testing or research operations.

2.3 Facility Operations

The Main Street facility is involved in the manufacture, development, and testing of jet engines and jet engine components. The facility has been used for the manufacture of aircraft engines and aircraft engine components since December 1929. Operations at the facility include, or have included in the past, metal parts machining, vapor degreasing, chemical etching, cleaning, electroplating, painting, assembly and testing, and research operations.

The Airport/Klondike Area was formerly used for experimental test operations as well as ancillary support operations for the factory main complex. There were various test stands or test cells for conducting test operations. Overall, most any type of testing for aircraft engine, jet-engine, and rocket components was conducted within the test stands. The various types of testing included airflow, erosion, combustion, fire resistance, anti-icing, sound abatement, foreign object ingestion, crosswind, and vertical takeoff or landing (VTOL) performance.

To support the testing operations, the test stands were provided with any or all of the following services and utilities: compressed air, oxygen, hydrogen, nitrogen, methane, propane, direct current (DC) and alternating current (AC) power (120, 240, and 480 volts), fuels (hard-piped or tank), fire protection equipment, and vacuum supply. The fuels for the test operations were

either supplied from a central tank farm, from local tanks in the particular area, or from containers.

For the ancillary support activities, the South Klondike Area was predominantly used for materials storage such as the storage of virgin product used in the manufacturing operations and wastes resulting from the production operations. Another support activity in the South Klondike Area was the Linde Gas Plant for the production of hydrogen from natural gas. Various areas within the Airport/Klondike Area were used to conduct fire-training exercises. Flammable and combustible materials were used in the fire-training exercises for the airport crash response team.

2.4 Area Descriptions

A general description of each of the sub-areas within the North Parcel is provided below with more detailed discussions regarding the specific environmental units within each sub-area provided in the applicable USTM included with this report. These environmental units were selected based on the types of activities conducted at each area and the potential for those activities to have adversely impacted the various environmental media at the Airport/Klondike Area including, soil, groundwater, surface water, and sediment. Although other areas of the Airport/Klondike may have been impacted by historic practices, no other specific potential contaminant source areas were evident from the available information.

The Airport/Klondike Area is located on the eastern portion of the P&W Main Street facility on the east side of the main plant, north of Brewer Street and south of Silver Lane. The Airport/Klondike Area consists of 4 study areas that include the North and South Airport Areas and the North and South Klondike Areas. For the North Parcel, portions of 2 of the study areas consisting of the North Airport Area and the North Klondike Area are included in the North Parcel. Within the portions of the 2 study areas present in the North Parcel, and addressed in this report, there are a total of 4 sub-areas. Within the 4 sub-areas, there are a total of 6 environmental units that are described in 5 USTMs. The layout of the North Parcel complete with the study areas and sub-areas is shown on Drawing 1.

2.4.1 North Airport Area

The North Airport Area is an approximately 211-acre area that generally includes the majority of the airport proper. Overall, the North Airport Area consists of two sub-areas comprised of a total of three environmental units that are described in two USTMs. The layout of the North Airport Area within the North Parcel is shown on Drawing 1. A brief description of the two sub-areas within the North Parcel is provided below.

2.4.1.1 Rentschler Airport

For purposes of this study, the Rentschler Airport Area is generally limited to the runway and taxi areas. The aircraft hangars and the airport terminal are not included, as these areas are not part of the North Parcel. The airfield was opened in 1931 as an all-turf airfield. Improvements were made through the years, which resulted in the present configuration of two main runways. The Rentschler Airport was used for the take-off and landing of a variety of commercial and military aircraft. Fueling, deicing and miscellaneous aircraft repair operations were conducted in other areas of the Main Street facility. Based on available information, it was determined that the fueling, repair and deicing operations were conducted at the airport hangars located near the Main Street facility. In addition, fueling also occurred in the Tie-Down Area located in the South Klondike Area.

Army Barracks that were used as temporary quarters of military personnel were once located on the northwestern portion of the airfield. The Army Barracks extended from the northern end of the north-south runway continued westward off the site. There were approximately thirty-three buildings (including barracks, mess hall, recreation, dispensary, supply and administration operations, warehouses, school, and radio) that were part of the Army Barracks complex. Fuel storage and vehicle maintenance areas or buildings were not indicated on the available drawing.

2.4.1.2 Former Silver Lane Pickle Company Area

Based on available information, the Silver Lane Pickle Company had a varied production line that included different kinds of pickles and vinegars, horseradish, horseradish root, chowchow, German mustard, pepper relish, onion relish, sauerkraut, piccalilli, dill tomatoes, ketchup, and chili sauce. The former Silver Lane Pickle Company had three different areas where there were underground storage tanks (USTs) of unknown sizes identified. All of the former USTs were located adjacent to buildings, based on the presence of fill pipes noted on a site plan (Peterson & Hoffman Engineers, 1964). From the northeast to the southwest, there were two USTs with a dispenser pump at one location, three USTs at a second location, and one UST at a third location. The former contents of the USTs are not known, but were likely to have been fuels.

The Silver Lane Pickle Company sold the property to United Aircraft in 1954 and 1963 with the former buildings being demolished in 1963 and 1964. Since 1964, the property has been undeveloped. Along the western boundary of the former Silver Lane Pickle Company Area, there are several contiguous piles of soil that contain various rubble and debris. The origin and reason why the soil piles were created is not known. It is possible that the soil piles were created during the demolition of the former buildings. The Silver Lane Pickle Company Area while being within the North Parcel is not within the Stadium Parcel.



2.4.2 North Klondike Area

The North Klondike Area is an approximately 116-acre area that generally includes the northern half of the area to the east of the airport. Overall, the North Klondike Area consists of ten sub-areas. The portion of the North Klondike Area that is included in the North Parcel consists of one of the ten sub-areas present within the North Klondike Area with two environmental units that are described in two USTMs. The layout of the North Klondike Area within the North Parcel is shown on Drawing 1. A brief description of the one sub-area within the North Parcel is provided below.

2.4.2.1 North Klondike Undeveloped Land Area

The land north and east of the developed portion of the North Klondike extends almost to Silver Lane to the north and Penney High School to the east. This area is mostly wooded, but has been cleared in some locations. Filling of low-lying areas and the accumulation of soil piles and debris have taken place along the western side of the North Klondike Undeveloped Land Area. Reportedly, this location has been used for parking lot sweepings and construction demolition materials. To the east of the soil piles, an area had been cleared, filled, and was used for the storage of vehicles. The area to the east has not been developed. Based on available information, the undeveloped area along the eastern edge of the Site has only been used for borrow material when filling and developing the airport.

2.5 Fire Insurance Maps

Database searches were performed to retrieve historical information available for the Main Street facility. LEA contracted with Environmental Data Resources, Inc. (EDR), of Southport, Connecticut, to search the available archives for Sanborn® Fire Insurance maps of the Site. The search revealed that twenty-four Sanborn® fire insurance maps were available for the general vicinity of the three P&W East Hartford facilities. Maps were available for the following years: 1903 (two maps); 1908 (three maps); 1913 (four maps); 1920 (four maps); 1927 (three maps); 1949 (three maps); and 1968 (five maps). However, the Sanborn Company never directly mapped the Main Street facility.

The 1903 Sanborn® maps show that the Main Street area of East Hartford was primarily a mixture of residences and tobacco sheds. The area to the northeast of the Brewer Street - Main Street intersection is labeled as "vacant".

The 1908 Sanborn® maps show that the Main Street area remained primarily a mixture of residences and tobacco sheds. The area presently occupied by a portion of UTRC and Rentschler

Airport was occupied at that time by the Silver Lane Pickle Company. The area to the northeast of the Brewer Street - Main Street intersection is still labeled as “vacant”.

The 1913 Sanborn® maps show that the area remained essentially the same as it was in 1908: a mixture of residences and tobacco sheds along Main Street. The 1913 maps show the Connecticut Tobacco Company offices and warehouses along Willow Street, approximately 1000 feet east of Main Street.

The 1920 Sanborn® maps show little change along Main Street in the area of the Main Street facility. A post office is shown on the northeast corner of the Brewer Street - Main Street intersection and the Connecticut Tobacco Company facility remains on Willow Street. The Silver Lane Pickle Company factory is still present.

The 1927 Sanborn® maps show that the Main Street area has remained unchanged along the eastside. However, two auto repair facilities have been established along the west side. The Silver Lane Pickle Company remains, and the post office is still shown to the northeast of the Brewer Street - Main Street intersection. A service station is shown just to the north of the post office and two gasoline tanks are indicated.

The 1949 Sanborn® maps show a general outline of the P&W buildings on Main Street. The former American Sumatra Tobacco Company offices are shown, labeled as “Pratt & Whitney Aircraft Company”, and a general outline of the western edge of the main factory building appears. The powerhouse is shown, as is the former Hamilton Standard Propellers company building south of the main P&W factory building. The 1949 map shows the expansion of the facility including the main plant, J Building, and the hangars with ancillary buildings. There was no mapping to the east of the P&W property.

The 1968 Sanborn® maps show the Main Street facility as belonging to P&W, but no mapping was done because admittance to the facility was refused. Mapping was not done to the east, probably because of the residential nature of the area. The area previously occupied by the Silver Lane Pickle Company was marked as belonging to P&W, the Pickle Company buildings were crossed off and the notation “all buildings removed” was evident on the maps.

2.6 Topographic Maps

EDR also reviewed and provided historical topographic mapping for the Main Street facility. The Main Street facility lies at the intersection of four quadrangles: Hartford North, Hartford South, Manchester, and Glastonbury. EDR provided copies of most but not all historical topographic maps for the Airport/Klondike Area. It should be noted that the information



provided below is based solely on map comparison for the years available, and parts of the information provided may contain gaps due to incomplete mapping.

The 1952 topographic map shows the Main Street facility at its present location and the Silver Lane Pickle Company facility in the vicinity of the current UTRC building. The Manchester quadrangle was not available for this year. The 1963/1964 topographic maps show the Silver Lane Pickle Company buildings removed and the UTRC building constructed. The P&W factory complex was in place.

The 1968/1972 topographic maps show the Main Street facility unchanged since 1963/1964, and the office buildings in the Rentschler Airport were shown as constructed. There was evidence of some construction of small buildings in the Klondike Area. The 1984 topographic maps show minor construction at the airport and additional construction in the Klondike Area. The 1992 topographic maps show some minor additions to the main factory buildings, an additional office building, some road construction, and some additional buildings in the Klondike Area.

2.7 Aerial Photograph Review

In an attempt to further identify past property usage, a review of available aerial photographs of the Airport/Klondike Area was performed. Aerial photographs of the Airport/Klondike Area were available from several sources. In addition to those on file and privately flown by P&W, aerial photographs were also on file with Connecticut Department of Environmental Protection (DEP), the Connecticut State Library Archives, the EPA, and various commercial sources. The majority of available aerial photographs were taken at high altitude and the resulting images were presented at a scale of approximately 1 inch equal to 1,000 feet, making the identification and interpretation of smaller structures and surficial features difficult.

A survey of aerial photographs available for the Site was also performed by EDR. EDR's review indicated that the readily available photograph was from 1951. A color infrared photograph was reported to be available from 1986. The origins of the photographs were not reported. The photographs are available from National Aerial Resources, Inc.

In addition, aerial photographs of the facility were taken in April 1990 by Golden Aerial Survey, Inc. in an effort to obtain an accurate topographic map of the facility. The topographic map developed based on the aerial photographs identified all buildings and roads at the facility at a scale of 1 inch equal to 200 feet.

As mentioned previously, aerial photographs were contained in the master files of the Environment, Health and Safety Group. Furthermore, a record of photographs (including aerial

photographs) of the Main Street facility is maintained by the P&W Photographic Services Department. A review of archive photographs from early 1930's until the present was conducted for those photographs that show the development and detail of the Airport/Klondike Area.

Aerial photographs on file with the DEP for the years of 1965, 1970, 1975, 1980, 1986, and 1990 were reviewed for those flight lines, which passed over the Airport/Klondike Area. The expansion and development of the Airport/Klondike Area was clearly visible in these photographs. Between 1965 and 1970, development of the South Klondike Area consisted of the original X-307 test stand, the area of drum storage south of the Cryogenics Building, the Quonset Hut, the six storage yards in the Virgin Products Storage Area, the Contractor Storage Area, and the new control tower on the south end of the airport.

The 1975 photographs show the lengthening of the airport runways. The 1980 photograph shows the construction of Fire Training Area A. In the 1986 photograph, the Linde Gas Plant has been replaced with the Chemical Storage Building. In general, the 1990 photograph shows lessened activity in the Klondike Area as indicated by smaller quantities of equipment and vehicles present.

Archive aerial photographs on file in the Connecticut State Library for 1934 and 1951 were reviewed for those flight lines, which passed over the Rentschler Airport and the Klondike Areas. In the 1934 photograph, the airport was new and there was no development of the Klondike Area. In the 1951 photograph, the first development of the North Klondike Area was visible.

A request was made to the EPA for information regarding aerial photographs. Apparently, the flight lines flown for the USGS are the same lines used by the EPA. The EPA had no specific flights over the East Hartford Area. A 1981 photograph obtained from the EPA included the Site, but did not have enough detail for use. No photographs were requested from the USGS due to similar coverage and the amount of processing time required to fulfill the request (approximately two to three months).

Large-scale aerial photographs for 1965, 1970, and 1975 were obtained from Keystone Aerial Surveys Inc. A large-scale aerial photograph for 1980 was obtained from AeroGraphics Corporation. These photographs were at a scale sufficient to provide a great deal of detail for the majority of the Airport/Klondike Area. Overall, these photographs provided confirmation of the information obtained from the various other photographs and sources of information. In general, pertinent information obtained from the aerial photographs is discussed in the individual USTM for a given environmental unit.



2.8 Summary of Previous Investigations

A summary of available information on previous investigations is provided in this section. The information is summarized by reference to the consultant that performed the investigation. The Airport/Klondike Area has been the subject of specific investigations and included in site-wide investigations related to environmental conditions since the mid 1960's. These reports and other sources of information were reviewed in an attempt to consolidate the information and evaluate the coverage to determine the focus of investigation and remediation. Other smaller reports and work in progress provided additional supporting data. A listing of reports for investigations conducted in the Airport/Klondike Area with specific reference or application to the North Parcel is included in the References at the end of this report.

Available information has been included in the USTMs for each of the environmental units. Much of the history of the use of these environmental units was found in the previous investigation reports. Other supporting information came from facility files or personal communications. This information was compiled from all of the available resources and included in the USTMs. A listing of specific references utilized in preparation of the USTMs has also been included at the end of each individual USTM. These USTMs are presented in separate volumes. Generally, the history of each unit is well documented. However, specific details regarding the operation of these units were not always available. Information on the review of available data was discussed previously.

2.8.1 Westinghouse Environmental and Geotechnical Services, Inc.

In 1990, Westinghouse Environmental and Geotechnical Services, Inc. (Westinghouse) completed a Current Assessment Summary (CAS) for the Main Street facility. Subsections of this report addressed the Airport/Klondike Areas. Concurrent with the preparation of the CAS, Westinghouse also prepared a Preliminary Reconnaissance Survey of the Airport/Klondike Area. The work by Westinghouse included documentation of past uses, field reconnaissance, an electromagnetic survey, a seismic refraction survey, aquifer testing, and soil and groundwater sampling associated with soil boring and monitoring well installations.

2.8.2 Haley & Aldrich, Inc.

In 1992 and 1993, Haley & Aldrich, Inc. (H&A) completed a Site-wide Environmental Monitoring Report for the Main Street facility. The work by H&A included soil and groundwater sampling associated with soil boring and monitoring well installations. Subsections of the H&A report discussed analytical results of subsurface, groundwater, surface water and sediment samples collected during the investigation activities.



2.8.3 Metcalf & Eddy, Inc.

Later in 1992 and 1993, Metcalf & Eddy, Inc. (M&E) completed Site Investigation Reports for the Airport/Klondike Area. The activities by M&E included a review of background data, a walk-through inspection, and environmental sampling. The environmental sampling included sampling and analysis of surface water, sediment, surface soil, subsurface soil, and groundwater. In these reports, the subsurface investigations focused on test stand areas in the North Klondike Area, the Virgin Products Storage Area (VPSA), the Cryogenics Area, and the Quonset Hut Area in the South Klondike.



3. INVESTIGATION METHODOLOGIES

Presented in this section are descriptions of the investigation methods and procedures employed during the Airport/Klondike Area investigation to characterize the nature and extent of contamination that might be present at the Airport/Klondike Area, and to support the remedial activities conducted at the Airport/Klondike Area. The review and evaluation of data from those previous investigations were presented in Section 2 of this report. The field sampling program described in the following subsections was designed to fill data gaps and to provide sufficient data to determine whether or not there had been a release(s) of hazardous substances or petroleum products at the Airport/Klondike Area.

The following sections provide a brief description of the approach, rationale, and types of investigation activities performed to characterize the environmental setting and to delineate contamination at the Airport/Klondike Area. These sections describe the procedures used to perform soil borings, conduct soil gas surveys, install monitoring wells, complete test pits, perform geophysical surveys and obtain samples of soil, soil gas, and groundwater. More detailed descriptions of specific investigation procedures are presented in the respective LEA Standard Operating Procedures, which are included in Appendix A of this report.

Section 6 provides an overview of the site investigation activities that were performed and includes a description of the approach, rationale, and types of investigation activities conducted to investigate the presence of contamination at the Airport/Klondike Area. As applicable, each USTM includes the rationale for conducting any investigation activities at that location, an outline of any investigation that was performed, analytical results from the investigation, and any conclusions based on the data collected. The overview of the results of the investigation activities is also provided in Section 6 of this report.

3.1 Location Identifiers

Monitoring wells, as well as piezometers, stream gauges, surface water and sediment sampling locations, and soil borings, have been provided with location identifiers using a systematic method to prevent duplication of location identifiers. The system of location identifiers provides a relatively easy means of finding the referenced locations on site maps. The P&W Main Street facility has been divided into twenty-six study areas. Each of the study areas has been assigned two-letter identifiers based upon the common name for the area. These two-letter designations are presented in Table 1.



In addition, each type of sampling location has been assigned a two-letter designation to identify the major sample type for a given sampling location. The two-letter designations for the various types of sampling locations are also presented in Table 1.

Because multiple samples were collected from a given test pit, an additional location identifier code was added to indicate which portion of the test pit the specific sample was collected from. This additional code took the form of a single letter appended to the end of the test pit identifier to indicate whether the sample was collected from the base or a wall, and, if from a wall, which wall. The specific codes associated with the test pit samples were: "N" for northern sidewall samples; "E" for eastern sidewall samples; "S" for southern sidewall samples; "W" for western sidewall samples; and, "B" for bottom samples. When additional soil removal was warranted, the subsequent soil samples were typically identified with additional suffixes such as "S1" for the first additional sample along a sidewall or excavation base, "S2" for the second, and so on.

Because of the large areas involved, the study areas that encompass the North Parcel include portions of the North Airport Area and the North Klondike Area. Monitoring and sampling locations have been given a location identifier based on their location in the Airport/Klondike Area, the type of sampling or monitoring location, and finally a sequential numeric identifier based upon the specific type of location. All soil sampling locations are presented on Drawing 2, which covers the North Parcel.

3.2 Soil Borings

Numerous soil borings have been installed in the North Parcel. The locations of these soil borings are shown on Drawing 2. Soil borings were generally completed to a depth of 16 feet below the ground surface, refusal, or the top of the clay unit, depending upon the purpose of the soil boring, the depth to the clay unit, and the general geologic material in the area. A depth of 16 feet was chosen because it exceeds the depth of 15 feet specified for the direct exposure criteria of RSRs.

Selected soil borings were completed to shallower depths where the soil borings were installed to provide confirmational samples for previous soil samples, or for other specific sample collection purposes. The general rationale for the location, total depths, analytical parameters, and sampling intervals for the specific soil borings is presented in the appropriate USTMs. The clay layer underlying the Airport/Klondike Area provides an effective barrier to vertical contaminant migration, and as such, soil borings were not typically continued when the clay unit was encountered.



3.2.1 Drilling Methods

Three drilling methods were used to install soil borings; both the historical soil borings and those installed as part of the current investigation activities. The methods used were hand augering, standard hollow-stem auger drilling with continuous split-spoon sampling techniques, and Geoprobe® direct-push techniques using the LEA Geoprobe® drilling rig. Each of these methods is briefly described below.

The soil borings installed during the most recent investigation activities were installed in general accordance with the procedures described in LEA Standard Operating Procedures (SOP) for *Geoprobe® Probing and Sampling, Geologic Logging of Unconsolidated Sedimentary Materials*, and *Soil Sampling* presented in Appendix A.

Hand augered soil borings were installed by manually advancing a stainless steel hand auger attached to an extendable handle. The auger was advanced until either the bucket was full, or the appropriate sampling depth was reached. The bucket was then retrieved and emptied. This process was continued until the final depth of the soil boring was reached. The hand auger bucket was decontaminated, in accordance with the LEA SOP for *Hand Auger Borings* presented in Appendix A, prior to collecting a sample.

The hollow-stem auger drilling method used continuous-flight hollow stem augers. The typical auger used had an inside diameter of 4.25 inches and a length of 5 feet. A pilot assembly, consisting of a surface-retractable plug for the lead-auger head, was used to avoid filling the augers with formation material. Continuous sampling with a split-spoon sampler was performed in advance of the augers. The split-spoon sampler consisted of a 24-inch long by 1.375-inch inside diameter steel sampling tube. The split-spoon sampler was driven through the 2-foot sampling interval with a 140-pound hammer with a 30-inch drop. After the split-spoon sampler was retrieved, the sampler was transferred to the attending geologist for sampling and logging. Drilling fluids were not required during the installation of soil borings using hollow-stem augers.

The direct-push techniques with the LEA Geoprobe® 5400 were used to install soil borings and both temporary and permanent monitoring wells. Direct-push techniques involved the initial installation of a soil boring to depth using Geoprobe® soil sampling techniques. Boreholes were advanced using the Geoprobe® Macro-Core® soil sampling equipment.

The Macro-Core® system consisted of a 48-inch long by 2-inch outside diameter steel sampling tube outfitted with disposable 46-inch long by 1.75-inch diameter polyethylene terephthalate copolyester (PETG) liners. The soil sampler was outfitted with a new liner and a fitted piston tip. The entire unit was driven to the top of the sampling interval with the Geoprobe® rig. The



purpose of the fitted piston tip was to seal the end of the sampling tube against the introduction of formation material during advancement. The piston tip was released by the operator, the sampler was driven to the final sampling depth by a combination of percussive hammering and direct pressure, and the sampler was retrieved. After the sampler was retrieved, the soil-filled liner was removed from the sampler and transferred to the attending geologist for sampling and logging.

3.2.2 Soil Sampling Methods

Soil samples collected from soil borings by LEA were sampled in general accordance with the procedures described in the LEA SOP for *Soil Sampling* presented in Appendix A. Continuous soil sampling was performed during the advancement of all boreholes installed at the Airport/Klondike Area by LEA. Soil sampling procedures were similar for split-spoon samples and for Geoprobe® Macro-Core® samples. Soil samples were collected from grade in 2-foot intervals down to the final depth.

Soil samples collected from hand augers were collected directly from the auger bucket immediately after retrieval from the borehole. The soil samples were transferred directly to laboratory-supplied sample containers using decontaminated stainless steel spatulas. Soil samples were collected in accordance with the LEA SOP for *Hand Auger Borings* presented in Appendix A.

For Geoprobe® borings, the Geoprobe sample liners were sliced open using a dedicated holding frame and razor knife immediately after collection. All soil samples were examined by the attending geologist for indications of contamination, such as the presence of visible free-phase petroleum, visible staining, or the incidental presence of odors. After collection, all soil samples were field headspace screened with a photo-ionization detector (PID) or flame-ionization detector (FID) for the presence of VOCs.

As soon as practical after the collection and opening of the sample liners, the soil samples were collected directly into laboratory-supplied glass sample containers with Teflon®-lined lids for submission to an off-site laboratory for analysis. Soil samples were collected from the opened liners using pre-cleaned stainless-steel spatulas. Filled sample containers were labeled using pre-printed, pre-numbered adhesive labels with the sampling date and time hand recorded by the sampler. The filled sample containers were placed into iced sample coolers for the remainder of the sampling day.

In addition to each sample collected for the off-site laboratory, selected soil samples were collected for the LEA Analytical Laboratory. An approximately 5-gram aliquot of the soil was



collected directly into a 40-milliliter (ml) vial with a Teflon[®] septum for analysis for target VOCs. Prior to collecting the sample, the analytical balance was tared against the weight of the vial. Soil samples were collected directly into the vials and the vials plus the soil were weighed to determine the actual weight of the soil sample collected. The vials were then filled to 30-ml volume with pre-preserved sampling water supplied by the LEA Analytical Laboratory. Filling of the vials was done by placing the vials into a wooden or plastic block, drilled to accept the vial, and sized to provide a top surface level with the 30-ml level of the vials. Filled sample vials were labeled using pre-printed, pre-numbered adhesive labels with the sampling date and time hand recorded by the sampler. The filled sample vials were placed into iced sample coolers for the remainder of the sampling day.

All soil samples collected as part of the Airport/Klondike investigation were analyzed in the LEA Analytical Laboratory for target VOCs, including benzene (BZ); chlorobenzene (CBZ), ethylbenzene (EBZ); tetrachloroethylene (PCE); toluene (TL); 1,1,1-trichloroethane (TCA); trichloroethylene (TCE); and, xylenes (XYL), using a gas chromatograph (GC). In the absence of detectable VOCs from the LEA Analytical Laboratory, soil samples were selected for laboratory analyses on the basis of the geologic logs, the field headspace screening, and consideration of potential contaminant release mechanisms. Soil samples run in the LEA Analytical Laboratory were analyzed and managed in accordance with the LEA SOP for the *Portable Gas Chromatograph and Sample Management Associated with the LEA Laboratory* presented in Appendix A.

3.2.3 Borehole Logging

After the retrieved soil was collected for laboratory analysis and field headspace screening, the attending geologist also visually described the soils using a modified Burmister Classification System. The geologic descriptions were recorded on standardized "Geologic Boring Log" forms in general accordance with the LEA SOP for *Geologic Logging of Unconsolidated Sedimentary Materials* presented in Appendix A.

The general data recorded for the subsurface materials encountered included the percentage of the sample recovered relative to the length of the sampled interval, the estimated primary grain size ranges according to the Burmister Classification Scheme, secondary grain size ranges, color, relative degree of water saturation, and visible sedimentary structures. In addition, the presence of extraneous materials and foreign objects was also recorded, as was the presence of odors or staining. Copies of available soil boring logs are included in Appendix B.

Soil borings were typically located in specific environmental units in response to the presence of contaminants. Because of this, and the fact that monitoring wells were typically advanced to



greater depths and located site-wide, the development of the geologic model for the Airport/Klondike Area was based on geologic information derived from monitoring wells logs. Geologic information derived from soil borings was used to supplement the data derived from the monitoring wells. Airport/Klondike Area geology is discussed in Section 5 of this report.

3.2.4 Borehole Abandonment

After completion of the sample collection, boreholes were abandoned to prevent the migration of contaminants into the aquifer through the open hole. Boreholes were abandoned by backfilling the open borehole with bentonite granules or small chips. The bentonite was poured slowly into the borehole to avoid bridging. The bentonite was hydrated with potable water to induce swelling and seal the borehole.

After backfilling the borehole, a surveyor's flag with the soil boring identifier was typically placed in the ground to temporarily locate the boring until a civil survey of the location could be completed. Soil boring locations were typically surveyed within two weeks of completion. Alternatively, the soil boring locations were located with the use of a tape measure in relation to other fixed Site features.

3.3 Test Pit Installation

Test pits in the Airport/Klondike Area have been installed in various locations generally to support subsequent soil excavation activities but also to supplement the focused soil boring program. Test pits have been installed at the Airport/Klondike Area since approximately 1996 by LEA. No indication of historical test pits has thus far been identified. This section describes the general procedures that were used during the installation of test pits at the Airport/Klondike Area. Also discussed are any variations and exceptions to the general methodology and the reasons why these variations and exceptions were required. All test pit locations in the North Parcel are presented on Drawing 3.

The test pits installed during the most recent investigation activities were in general accordance with the procedures described in LEA SOPs for *Soil Sampling*, and *Geologic Logging of Unconsolidated Sedimentary Materials* presented in Appendix A.

3.3.1 Test Pit Excavation Methods

Test pits were excavated using commercial excavators under the direction of LEA field personnel. Experienced operators operated all heavy equipment. For the removal activities, excavations were typically begun at a given location of the area to be removed. To supplement the focused soil boring program, excavations were typically begun in a location where a broader

view of the subsurface materials was desired. These areas included the former Silver Lane Pickle Company Soil Piles, along with the North Klondike Undeveloped Land Soil Piles and the Outside Storage Area.

For the removal activities, soil excavation at each test pit location continued laterally until all visually contaminated soil was excavated. For the investigation activities, soil excavation at each test pit location continued laterally until a large enough area was exposed for inspection and sample collection. Soil excavation was generally limited vertically by the depth to the groundwater table. For most of the test pits, soil excavation was concluded at the water table, in some cases additional soil was removed in order to facilitate the removal of a structure, or when infiltration of groundwater was so slow that the true phreatic surface was not discovered until the following day. Soil samples were collected from the base and sidewalls of the excavations to confirm that the excavation was inclusive of all contaminated soil. In the event exceedances of any applicable tabulated numeric criteria were detected in a sample, additional soil was excavated in the direction of the exceedance, and the new perimeter of the test pit was re-sampled.

For removal activities, excavated soil was placed into lined, covered roll-off containers to await off-site disposal or into waiting dump trucks for immediate transportation off the Site. Where possible, separate roll-off containers were used for each separate excavation to prevent mixing of the soils. For investigation activities, excavated soil was placed adjacent to the test pit and then used to backfill the excavation.

3.3.2 Test Pit Sampling Methods

Soil samples collected from test pits were sampled in general accordance with the procedures described in the LEA SOP for *Soil Sampling* presented in Appendix A. Soil sampling was performed after the completion of the test pit excavation. Soil sampling procedures were similar for all test pits.

In all areas where remediation by means of soil removal was performed, confirmational soil samples were used to confirm the vertical and horizontal extent of the contamination and to document that soil had been remediated to a point where any remaining levels were below the applicable tabulated numeric criteria. When the specified limits of the excavation were reached or when field observations indicated that the contaminants had been removed, a confirmatory sample was obtained by using either a composite or grab sampling method. Following analysis, the analytical results for a confirmatory sample were reviewed. If the constituents analyzed exceeded the applicable tabulated numeric criteria, the excavation was extended and additional sampling performed. If the constituents were below the applicable tabulated numeric criteria,

excavation activities in the area represented by the sample were ceased. A description of the sampling methods is provided below.

After the completion of the test pit, soil samples were collected from the excavation sidewalls and bottom, as appropriate, directly into laboratory supplied, Teflon[®]-lined sample containers. The soil samples were grab samples collected approximately 3 to 6 inches below the surface. The soil samples were typically located randomly along the excavation face. When indications of potential contamination (i.e., staining, odors, discoloration, etc.) were observed, the grab sample was collected judgmentally from the area that represented potential contaminated conditions. All soil samples were examined by the attending LEA field personnel for indications of contamination, such as the presence of visible free-phase petroleum, visible staining, or the presence of odors. Soil samples were collected directly into laboratory-supplied sample containers with Teflon[®]-lined lids for submission to an off-site laboratory for possible analysis. After collection, soil samples were typically field headspace screened with either a PID or FID for the presence of VOCs.

Soil samples were collected using pre-cleaned stainless-steel spatulas. Filled sample containers were labeled using pre-printed, pre-numbered adhesive labels with the sampling date and time hand recorded by the sampler. The filled sample containers were placed into iced sample coolers for the remainder of the sampling day.

Occasionally, samples were collected for the LEA Analytical Laboratory. A 5-gram aliquot of the soil was collected directly into a 40-milliliter vial with a Teflon[®] septum for analysis for target VOCs. Prior to collecting the sample, the analytical balance was tared against the weight of the vial. Soil samples were collected directly into the vials and the vials plus the soil were weighed to determine the weight of the soil sample collected. The vials were then filled to 30-milliliters volume with pre-preserved sampling water supplied by the LEA Analytical Laboratory. Filling of the vials was done by placing the vials into a wooden or plastic block, drilled to accept the vial, and sized to provide a top surface level with the 30-milliliter level of the vials. Filled sample vials were labeled using pre-printed, pre-numbered adhesive labels with the sampling date and time hand recorded by the sampler. The filled sample vials were placed into iced sample coolers for the remainder of the sampling day.

3.3.3 Test Pit Logging

After the retrieved soil was collected for laboratory analysis and field headspace screening, the attending LEA field personnel also visually described the soils using a modified Burmister Classification System. The geologic descriptions were recorded on standardized "Test Pit Log"



forms in general accordance with the LEA SOP for *Geologic Logging of Unconsolidated Sedimentary Materials* presented in Appendix A.

The general data recorded for the subsurface materials encountered included the estimated primary grain size ranges according to the Burmister Classification Scheme, secondary grain size ranges, color, relative degree of water saturation, and visible sedimentary structures. In addition, the presence of extraneous materials and foreign objects was also recorded, as was the presence of odors or staining. Copies of available test pit logs are included in Appendix C.

3.3.4 Test Pit Abandonment

After the completion of soil sampling and geologic logging, test pits completed as part of the remediation activities were generally not abandoned, but were fenced and/or covered to provide personnel protection, and left open until analytical data became available. The rationale for leaving the test pits open was to facilitate additional soil removal, should it be necessary. Upon receipt and evaluation of the analytical data, additional soil was removed as necessary and the excavation backfilled with material from an off-site borrow source. After excavation, the location of each test pit was surveyed to provide horizontal location data. Test pit locations were typically surveyed within two weeks of completion.

3.4 Soil Vapor Surveying

Soil vapor surveys were performed as part of the Airport/Klondike Area investigation activities to provide an indication of the presence and relative magnitude and the distribution of contaminants in the unconsolidated materials in various locations at the Airport/Klondike Area. The soil vapor surveying completed during the most recent investigation activities was in general accordance with the procedures described in LEA SOP for *Soil Vapor Surveying* presented in Appendix A.

3.4.1 Soil Vapor Surveying Point Locations and Rationale

One soil vapor survey has been completed in the North Parcel over the course of the Airport/Klondike Area investigations. This soil vapor survey was completed both as part of investigations of soil quality in specific environmental units and areas. A soil vapor survey was conducted in the former Silver Lane Pickle Company in 1997. This soil vapor survey was located on the basis of historical information regarding Airport/Klondike Area operations, on the basis of field observations made during numerous Airport/Klondike Area walkovers and visits, and on information gathered during other phases of the environmental investigation of the Airport/Klondike Area.



3.4.2 Soil Vapor Probe Installation Methods

Soil vapor surveys were initiated by locating the proposed soil vapor survey locations by LEA field personnel. After the proposed soil vapor survey points were located, an auger hole was advanced through any pavement or other restrictive layer, if appropriate. After the auger hole was completed, a pilot hole was drilled and/or punched to a depth of approximately 6-inches shallower than the proposed depth of the soil vapor point.

After the pilot hole was completed, the soil vapor probe was inserted into the pilot hole and driven to depth into undisturbed sediments. The soil vapor probe consisted of a length of stainless steel tubing to which is fitted a sampling tip. The vapor sampling tip consisted of a short, approximately 2-inch long, stainless steel tubing punctured by small holes, fitted at the top and bottom with larger-diameter, stainless-steel blank sections each approximately 2 inches long. The top of the vapor probe was fitted with a vapor-tight Swagelok® connector to allow coupling the vapor probe to the appropriate tubing. The larger-diameter, stainless-steel blank sections were there to provide slightly over-sized sections to seal-off the hole around the perforated portion of the vapor probe.

After the vapor probe had been driven to depth, the pilot hole opening was sealed to prevent flow of ambient air into the vapor probe. The pilot hole was typically sealed using modeling clay that provided an impermeable material that could be molded to fit the pilot hole opening and formed snugly against the vapor probe. Once the soil vapor probe was installed in the hole and the hole sealed, the probe was attached to the sampling apparatus and sampling was commenced.

3.5 Vapor Sampling Methods

Soil vapor samples collected from vapor probes were collected in general accordance with the procedures described in the LEA SOP for *Soil Vapor Surveying* presented in Appendix A. Soil vapor sampling procedures were similar for all sampling locations.

Once the soil vapor probe was installed in the pilot hole, the probe was attached to the sampling apparatus by one of two methods. For the North Airport Area, with relatively low levels of contamination, the vapor probe was attached to Tygon® tubing. The Tygon® tubing was attached directly to the sampling system. The sampling system consisted of an air pump and a flow meter with the appropriate valves for controlling vapor flow through the system. After the system was connected, the probe was purged of a minimum of three volumes of vapor. After purging, a sample of the soil vapor was collected into a Tedlar® bag for subsequent laboratory analysis. Because only field screening results were required, the sampling pump was replaced by a FID and the concentration of total ionizable constituents was recorded.

After the Tedlar[®] bag was filled, the bag was transferred to a chilled cooler to await field analysis. Field analysis was performed using a portable FID. The purpose of the field analysis was to provide a qualitative measure of the presence and location of contamination in the subsurface. The field data were subsequently used to guide a focused soil boring program, rather than to provide a quantitative measure of any subsurface contamination.

In the event that additional soil vapor samples were desired from the current location, the probe was manually advanced to the next target depth. If manually advancing the probe was not possible due to the nature of the subsurface materials, the probe was extracted from the pilot hole and the pilot hole advanced manually.

Analytical parameters for soil vapor samples collected from the North Airport Area were total ionizable VOCs. Specific contaminants of concern were not chosen because the field data were subsequently used in a qualitative manner to guide a focused soil boring program, rather than to provide a quantitative measure of any subsurface contamination.

3.5.1 Pilot Hole Abandonment

After the completion of the soil vapor sampling, the vapor probe was extracted from the pilot hole and the pilot hole was allowed to collapse. Where possible, the pilot hole was backfilled with bentonite to the ground surface.

3.6 Groundwater Sampling

The purpose of the groundwater characterization portion of the environmental setting investigation was to define groundwater elevations and aquifer characteristics across the Airport/Klondike Area. The object was to characterize the hydrogeologic characteristics and groundwater flow regime across the Airport/Klondike Area in order to understand and evaluate potential contaminant fate and transport pathways and mechanisms.

This section describes the installation of new monitoring wells, aquifer testing methodologies, and the collection of water-level measurements. Monitoring wells have been installed at the Airport/Klondike Area over the course of several years as parts of a variety of environmental investigations. Monitoring wells and piezometers have been installed to provide overall groundwater flow patterns, overall groundwater quality, water-table elevation data for Rentschler Airport drainage, and environmental unit-specific groundwater quality information. In general, monitoring wells and piezometers installed by LEA have been designed to address specific groundwater quality issues in areas of known or suspected groundwater contamination, or to provide additional background groundwater quality and water-table elevation data.

In many cases, these monitoring wells were located on the basis of historical information regarding Airport/Klondike Area operations, or on the basis of field observations made during numerous Airport/Klondike Area walkovers and visits. Information on historical operations has been obtained from various reports, aerial photographs, engineering drawings and plans, and P&W internal memoranda. More detail on historical operations is included in other portions of this report as well as in the USTMs.

Based on information collected from existing monitoring wells, monitoring wells and piezometers installed during this Airport/Klondike Area investigation have been screened in the upper portion of the unconsolidated aquifer. Monitoring wells and piezometers have been installed to address specific potential contaminant release issues and to supplement the existing monitoring well network. In some cases, the location of a monitoring well has been chosen on the basis of groundwater quality information collected from Geoprobe® screenpoint groundwater samples. In other cases, monitoring wells have been located on the basis of soil quality data derived from the soil boring program.

3.6.1 Well Locations

The installation of shallow wells has been conducted over a period of years in response to the needs of various environmental investigations. A summary for the location rationale for the monitoring wells and piezometers within the North Parcel is presented below.

- NA-MW-01 Areal coverage - North Airport
- NA-MW-05 Former Silver Lane Pickle Company
- NA-MW-06 Former Silver Lane Pickle Company
- NA-MW-07 Former Silver Lane Pickle Company
- NK-MW-06 North Klondike Undeveloped Land Area Outside Storage Area
- NK-MW-17 North Klondike Undeveloped Land Area Soil Piles

A total of six shallow well locations have been installed in the North Parcel to address either hydrogeologic or water-quality data gaps. All groundwater sampling locations in the North Parcel are presented on Drawing 4. In the North Airport Area, monitoring well NA-MW-01 was installed in October 1991 by H&A during the Site-Wide Environmental Monitoring Program at the Main Street facility. In the North Airport, monitoring wells NA-MW-05 through NA-MW-07 were installed by LEA during the most recent Airport/Klondike Area investigations. In the North Klondike Area, monitoring well NK-MW-06 was installed in October 1991 by H&A during the Site-Wide Environmental Monitoring Program. Monitoring well NK-MW-17 was installed in about April 1993 by M&E during the Klondike Area Site Investigation.



3.6.2 Installation of Monitoring Wells

Monitoring wells in the Airport/Klondike Area have been installed by conventional hollow-stem auger drilling rigs and by direct-push techniques using the LEA Geoprobe® drilling rig. Monitoring wells have been installed at the Site since approximately 1980. This section discusses the installation methods and soil sampling procedures used to install the monitoring wells emplaced at the Airport/Klondike Area since approximately 1990. Where possible, reference is made to techniques and methodologies used to install existing monitoring wells by previous consultants and contractors. However, this information has been taken from available literature and does not constitute first-hand knowledge of the installation procedures or sampling methodologies. In addition, some information regarding monitoring well construction and/or soil sampling was not reported.

Two drilling methods were used to install monitoring wells, both historical monitoring wells and those installed as part of the most recent investigation activities, in the Airport/Klondike Area. The methods used were hollow-stem augering and Geoprobe® direct-push techniques. Each of these methods was described previously.

Following completion of each borehole to the desired depth, monitoring wells were installed in general accordance with the LEA SOP for *Monitoring Well Installation* presented in Appendix A. The screened interval for the monitoring well was specified by the geologist based on the observed depth to water, the materials encountered, and the presumed water-table fluctuations to be expected.

During monitoring well installations, additional information regarding the monitoring well construction details was recorded on standardized "Monitoring Well Construction" log forms in accordance with the LEA SOP for *Monitoring Well Installation*. The general information recorded included the types and construction of the well materials, the screened interval, the dimensions and materials of the filter pack, the backfill materials, and the surface completion of the monitoring well.

3.6.2.1 Well Construction

The monitoring wells were constructed of 2-inch diameter, Schedule 40 polyvinyl chloride (PVC) flush-threaded screen and casing, except at specific wells (i.e., NA-MW-05 through NA-MW-07) where 0.5-inch diameter, Schedule 40 PVC Geoprobe® Prepack screen and casing were installed with the Geoprobe®. Construction materials and procedures for the standard monitoring wells were in general accordance with the *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*, OSWER-9950.1 and the *Handbook of Suggested Practices*



for the Design and Installation of Groundwater Monitoring Wells (EPA 600/4-89/034) (U.S. EPA/NWWA, 1989).

Screen lengths for all of the shallow monitoring wells were no longer 10 feet. Screens for the shallow wells were positioned across the water table, as observed at the time of installation, with approximately 5 to 7 feet of screen placed below the water table. For the intermediate and deep wells, 5-foot screen lengths were used. The screened intervals for the intermediate and deep wells were determined based on observations made during soil sampling (i.e., visual indications, odor, or screening for volatile organics) and the intended vertical position within the aquifer.

In addition to the permanent groundwater monitoring wells installed throughout the Airport/Klondike Area, Geoprobe® screenpoint samples were collected from discrete locations. Geoprobe® Screen-Point samplers are temporarily emplaced sampling devices consisting of a stainless-steel well screen driven to the desired sampling depth and unsheathed. Groundwater samples are collected as if from monitoring wells, however, the sampling devices remain in the borehole only as long as necessary to collect the sample. The techniques used to collect screenpoint groundwater samples are detailed below. Screenpoint groundwater samples were used to supplement the groundwater quality data collected from the permanent monitoring well network and to direct the location of permanent monitoring wells.

3.6.2.2 Installation of Standard Monitoring Wells

For monitoring wells installed with conventional hollow-stem auger drill rigs, 2-inch diameter PVC well materials were selected based on the need to allow groundwater sampling and minimize the volume of waste soil and purge water generated.

The 2-inch PVC well material was installed in the borehole to the specified depth interval. All PVC well materials were pre-cleaned by the manufacturer and kept in the sealed packaging prior to installation in the borehole. From bottom to top, the well materials consisted of a 2-inch diameter PVC end cap, a 5- or 10-foot length of 0.010-inch (No. 10 slot) mill-slotted PVC screen, and an appropriate length of 2-inch diameter PVC blank casing (riser). The well materials were joined by factory-threaded ends. Total well screen lengths were kept to 10 feet or less to allow sampling of discrete intervals while allowing a sufficient length of open screen for water-table fluctuations.

After the well materials were in place, a filter sand pack was installed from the bottom of the screened interval to a depth of at least 6 inches above the screened interval. The shallow thickness of filter pack above the screened interval was necessary in some cases due to the shallow depth to water and the need to provide a sufficient length of screen above the existing



water table to allow for natural water-table fluctuations throughout the year while also leaving space for completion of the necessary components for well construction. The filter pack material was typically chosen based on previous field experience at the Airport/Klondike Area. The filter pack material typically consisted of Morie No. 00, No. 0, or No.1 sand, or the equivalent.

Above the filter pack, a bentonite chip or pellet seal was placed to prevent surface contamination from entering the well screen. The thickness of the annular seal ranged from approximately 6 inches to 2 feet depending on the available annular space. The bentonite seal was hydrated with potable or distilled water when placed above the water table. Typically, the annular seal was made sufficiently thick so that the top of the annular seal was coincident with the base of the concrete pad.

Monitoring wells were completed with either above-grade or at-grade wellhead completions, depending upon the anticipated level of traffic in the vicinity of the well. The concrete pads on all monitoring wells were originally intended to be 3 foot by 3 foot by 3 foot. However, due to the shallow depth to groundwater in some areas of the Site, some concrete pads were as thin as 2 feet. Above-grade wellhead completions consisted of protective steel casings with locking caps. The protective casings were approximately 5 feet long with the base of the protector placed approximately at the bottom of the concrete pads. The top of the protective casing was approximately 0.2 to 0.4 feet above the top of the PVC riser. At-grade wellhead completions consisted of a steel protective roadbox and a locking plug for the monitoring well PVC riser. The concrete pads were constructed so as to slope away from the monitoring well to allow precipitation to drain away from the protector and not pond at the well. A survey reference point was installed at all monitoring well locations installed by conventional drilling rigs.

3.6.2.3 Installation of Geoprobe® Prepack Monitoring Wells

Direct-push techniques with the LEA Geoprobe® 5400 were used to install both temporary and permanent monitoring wells. Direct-push techniques for permanent monitoring well installations involved the initial installation of a soil boring to depth using Geoprobe® soil sampling techniques. Boreholes were advanced using the Geoprobe® Macro-Core® soil sampling equipment. Upon completion of the soil boring, an installation casing, sealed at the tip with an expendable stainless-steel point, was advanced to depth. The expendable stainless-steel drive point was used to avoid filling the casing with formation material.

The installation casing was a 2.125-inch outside diameter threaded steel casing with an expendable drive point at the downhole end. The expendable drive point was held in-place during casing advancement by an O-ring. The O-ring also maintained the watertight integrity of



the casing during advancement to depth. The monitoring well was installed within the installation casing.

The base of the screened section of the Geoprobe® monitoring well was fitted with a coupling, which attached to the expendable drive point and anchored the screen and riser into place. The prepack screened sections were composed of interlocking, 3-foot long, 0.5-inch diameter, 0.010-inch slotted Schedule 80 PVC surrounded by a 1.5-inch diameter stainless steel mesh which holds the filter pack sand in place. The filter pack consisted of a 20/40-grade silica sand.

The prepack screens were placed into the installation casing and an appropriate length of 0.5-inch diameter Schedule 80 PVC riser was attached. After lowering the well sections to the base of the casing, the well was attached to the expendable drive point by driving the well down sharply. After the well was attached to the drive point, the installation casing was withdrawn from the borehole while an approximately 2-foot thick sand cap was placed above the screen. The purpose of the sand cap was to isolate the screened interval from the bentonite seal and prevent bentonite from infiltrating into the screen. A bentonite seal was placed above the sand cap. This seal was typically brought to the surface in the Airport/Klondike Area due to the relatively shallow depth to the water table. The monitoring wells were completed with either above-grade or at-grade wellhead completions similar to those described above for standard monitoring wells.

Temporary monitoring wells were used in instances where a groundwater sample was required and where a water-table elevation measurement may also have been desired. Temporary monitoring wells were not completed with roadboxes, filter packs, or bentonite seals, but were typically constructed of 1-inch diameter Schedule 80 PVC screen and riser installed directly in the open borehole and sampled immediately.

In some instances, a small amount of filter pack sand was added to stabilize the borehole, but a bentonite seal was not typically used because of the possible difficulty in removing the temporary well. Temporary wells were not left in place for extended periods of time. These temporary wells were installed only for as long as necessary to collect a groundwater sample, to survey the elevation, or to collect water-table elevation data. Temporary monitoring wells were removed and the boreholes abandoned by filling with bentonite.

3.6.2.4 Installation of Screenpoint Samples

Screenpoint groundwater samples were collected using a Geoprobe® Screen-Point Sampler® prior to approximately February 1997 and a Geoprobe® SP-15 Screen-Point Sampler® since approximately February 1997. Screenpoint sampling devices were typically employed in



“unsampled” boreholes within 6 to 12 inches of “sampled” boreholes. In this manner, the groundwater samples collected from the screenpoint sampling devices represent undisturbed groundwater from the same interval as the corresponding soil samples from the immediately adjacent soil borings.

The Screen-Point Sampler[®] consisted of a 22-inch long, stainless-steel wire mesh insert and sleeve that was driven to depth in a protective sheath with an expendable drive point. The wire mesh insert and sleeve were held in place in the protective sheath by the expendable drive point which in turn was held in place by inert O-ring seals and the pressure of being pushed through the formation. After the screen was driven to depth, the drill rods were retracted approximately 24 inches, and the expendable drive point remained in place, creating a void in the formation. The Screen-Point Sampler[®] was manually extended into the void while the sheath and drill rods sealed the borehole above the sampler. After the sampler had been emplaced, a groundwater sample was collected using standard sampling techniques. Groundwater sampling methodologies are discussed below.

The SP-15 Screen-Point Sampler[®] consisted of an approximately 42-inch long, stainless steel, wire-wound screen and metal sheath provided with an expendable drive point. After the screen was driven to depth, the drill rods were retracted approximately 44 inches, and the expendable drive point remained in place, creating a void in the formation. The SP-15 screen was manually extended into the void while the sheath and drill rods sealed the borehole above the sampler. After the sampler has been emplaced, a groundwater sample was collected using standard techniques. Groundwater sampling methodologies and results are discussed below.

After the collection of groundwater samples from either a Screen-Point Sampler[®] or a SP-15 Screen-Point Sampler[®], the screens, sheaths, and drill rods were removed, and the expendable drive points remained in place as the borehole was abandoned by filling with bentonite.

3.6.3 Well Development

Monitoring wells were developed in accordance with the procedures outlined in the LEA SOP for *Monitoring Well Installation* presented in Appendix A. Development waters were originally placed into portable containers until they were placed into 55-gallon drums as described in earlier.

Monitoring wells were developed by alternately over-pumping, using a submersible pump to draw down the water level in the well, and surging to flush fine sediment from the aquifer through the screen to be subsequently removed. After the well was initially pumped, the well was then surged using a surge block or inertial pump. With the surge block or inertial pump, the

well was surged beginning at the bottom of the screened interval and working upward to the top of the screen. After surging, the well was pumped to remove suspended sediments. This cycle was repeated until the well development criteria had been met.

Monitoring wells were developed until the following criteria were met:

- Removal of at least three well volumes.
- Stability of the physical parameters of temperature and specific conductance. Values for these parameters must be within ten percent over three sequential water samples with a minimum of one well volume extracted between samples.
- Turbidity must be less than approximately twenty Nephelometric turbidity units (NTU) at completion, and the water must be clear.
- The pH must be lower than 9.0 and stable within 0.1 pH unit.

Completed monitoring wells were developed no sooner than 72 hours after well completion to allow grout materials time to set up. Development was performed to remove fine sediment from the well, the screen openings, and filter pack and to facilitate groundwater flow to the well. Development procedures included pumping and surging using a surge block and submersible or inertial pumping methods. Development of Geoprobe® Prepack monitoring wells was performed by pumping, since the small internal diameter of these wells does not allow effective surging.

3.6.4 Water-Level Measurements

Groundwater elevations were measured in all newly installed wells and existing wells using an electronic water-level measurement device. Manual water-level measurements were made by LEA personnel in general accordance with the techniques described in the LEA SOP for *Liquid Sample Collection and Field Analysis*. Depth to water was measured to the nearest 0.01 foot using an electronic water-level indicator. The depth to water measurements were made relative to the surveyed reference mark for each water-level measurement point (i.e., monitoring well, piezometer, etc.). Measurement of water levels on a site-wide basis must be performed rapidly to minimize the errors resulting from time-dependent effects, such as recharge from precipitation. The task of measuring water levels was typically performed by LEA personnel in a single day.

Reference elevations for the monitoring wells were surveyed to the National Geodetic Vertical Datum (NGVD) of 1929. Water-level measurements were collected on various occasions beginning in 1990, and continuing through 1998. Data from select measuring events were used



to produce contour maps of water-table elevations and to evaluate horizontal and vertical hydraulic gradients within the aquifer. A contour map for a June 1997 groundwater sampling event is presented on Drawing 4.

Manual water-level measurements were made by slowly lowering a decontaminated electronic water-level indicator probe into the monitoring well until the unit indicated that the water surface had been breached. The depth to water was read from the calibrated cord suspending the probe and recorded in the field paperwork. Depths to water were converted to water-table elevations based upon the surveyed reference point elevations.

3.6.5 Groundwater Sample Collection

Depending on the type of the groundwater sampling point, several differed methods for groundwater sample collection were employed as discussed below.

3.6.5.1 Monitoring Well Sampling

All monitoring wells were sampled in accordance with LEA SOP for *Liquid Sample Collection and Field Analysis* presented in Appendix A, with some additions and modifications. The general sampling procedure is summarized below.

After opening the well cap, the sampling team measured the depth to water and the depth to the base of the well using either an electronic water-level indicator or a decontaminated fiberglass tape and sounder. Water-level measurements were recorded to the nearest 0.01 feet. The data were recorded on LEA's "Groundwater Field Data Record" forms. Water levels were obtained before purging activities began. The measurements were used to calculate the volume of water in the well, and the calculations were recorded on the field forms.

An initial set of pH, temperature, and specific conductance readings was obtained at the initiation of purging. Purging was performed with peristaltic pumps with disposable tubing. Additional field parameter readings (pH, temperature, and conductivity) were obtained and recorded after the removal of each well volume.

Purging continued until the most stringent of the following requirements had been met:

- At least three well volumes had been extracted from the well (except if the well was purged dry, then it was sampled after recharging).
- The measured field parameters had stabilized within ± 0.5 pH units, ± 10 percent for specific conductance, and $\pm 1^\circ$ Fahrenheit for temperature.



During monitoring well sampling, a disposable Teflon[®] bailer was used to collect groundwater samples for analyses of VOCs. Samples were collected directly from the bailer by pouring gently into 40-ml glass vials. All other samples were collected with the peristaltic pump by using new tubing at each well. The samples for dissolved metals analyses were field filtered with 0.45-micron cellulose acetate high-capacity in-line filters attached directly to the discharge tubing. The samples requiring collection with a Teflon[®] bailer were taken last. Following collection, samples were placed in a cooler maintained at a temperature of 4° Celsius for transportation to the laboratory.

Samples were identified on the sample containers and chains-of-custody by a sample number only; the well location was not identified to the laboratory. Duplicate samples were given separate sample numbers and were not identified as duplicates to the laboratory. The samples were placed into pre-preserved bottles, as appropriate, upon being collected. Chain-of-custody forms were prepared and were submitted to the laboratory with the samples by LEA personnel.

Daily trip blanks were submitted with the samples, and were analyzed for VOCs. Duplicate samples for quality control were collected at a minimum of one per twenty samples during the sampling round. Equipment blanks were collected at a minimum of one per twenty samples, and were analyzed for all analytes collected on that particular day of sampling.

Following collection, samples were placed in an iced cooler for transportation to the laboratory. All samples were maintained under proper custody protocols from the time of collection until they were relinquished to the custody of the laboratory personnel.

Samples were identified on the sample containers and chains-of-custody by a sample number only; the well location was not identified to the laboratory. Duplicate samples were given separate sample numbers and were not identified as duplicates to the laboratory. The samples were placed into pre-preserved bottles, as appropriate, upon being collected. Chain-of-custody forms were prepared and were submitted to the laboratory with the samples by LEA personnel. All sample collection and handling procedures were performed in general accordance with the LEA SOP for *Liquid Sample Collection and Field Analysis* presented in Appendix A.

3.6.5.2 Geoprobe[®] Screenpoint Sampling

Groundwater samples were collected using the Geoprobe[®] screenpoint sampler from soil borings, which were advanced with the Geoprobe[®]. This technique involved installing a Geoprobe[®] Screenpoint sampler adjacent to the original borehole. A location adjacent to the original borehole was chosen so that the boring could be completed to the final depth without interruption and so that the screenpoint sampler could be installed in undisturbed sediments. The

offset of the screenpoint sample from the original borehole was typically 6 to 12 inches.

The screenpoint sampler consisted of various lengths of stainless-steel wire mesh insert and sleeve that was driven to depth in a protective sheath with an expendable drive point. After the screen was driven to depth, the drill rods were retracted, and the expendable drive point remained in place, creating a void in the formation. The screenpoint sampler was manually extended into the void while the sheath and drill rods sealed the borehole above the sampler.

After the sampler has been emplaced, a groundwater sample was collected using standard techniques. With the use of a low-flow peristaltic pump and disposable tubing, the sampler was purged of a small amount of groundwater in order to fill the tubing. The groundwater samples were then collected directly into the appropriate sample containers. These samples were labeled, handled, and stored in the same manner as described above.

3.7 Geophysical Survey

Geophysical surveying was conducted in the Airport/Klondike Area using various techniques in order to:

- Define the upper surface of the glaciolacustrine sediments in the South Klondike Area;
- Locate and determine the boundaries of former septic systems associated with the former Army Barracks area located in the North Airport Area;
- Determine the existence of the magnetic anomalies in the Airport/Klondike Area; and,
- Determine the depth to bedrock in the Airport Area.

3.7.1 Geophysical Surveying Techniques

Various geophysical surveying techniques have been applied at the Airport/Klondike Area to provide different information regarding the nature of the surficial materials at the Airport/Klondike Area. These methods include seismic refraction surveying, electromagnetic surveying, ground penetrating radar surveying, and magnetometry.

Seismic refraction surveying consists of measuring the time it takes sound waves to travel through materials and relating that time to the nature of the materials. Seismic refraction surveying uses a system of vibration-sensitive receivers to detect and record sonic energy



refracted from subsurface horizons. Seismic refraction surveying has been used in the Airport Area to define the depth to bedrock and the general nature of the unconsolidated materials.

Electromagnetic surveying consists of measuring the response of the geologic materials to induced electromagnetic fields. Electromagnetic surveying uses a coupled transmitter and receiver to induce and measure electromagnetic eddy currents in buried conductive objects. Electromagnetic surveying has typically been used to locate areas where buried metallic objects may be located.

Ground penetrating radar (GPR) surveying consists of recording and converting radar signals reflected from subsurface materials. The GPR system transmits and receives pulsed electromagnetic energy and converts the received signals into indications of the change of the dielectric constants between subsurface materials or buried objects. GPR surveying has typically been used to locate buried objects, such as pipes or tanks that have significantly different dielectric properties from the surrounding soil.

Magnetometry is the measurement of variations in the normal magnetic field caused by the presence of buried magnetically susceptible objects. The magnetometry system consists of a magnetic field detector mounted on a staff to provide a constant height above the ground surface and connected to a recording device. Magnetometry is typically used to locate buried metallic objects.

This section presents the general procedures and methodologies used to conduct and analyze the data from the various geophysical surveying techniques used in the Airport/Klondike Area. These methods were used by LEA and also by previous consultants and contractors who performed geophysical surveying at the Site.

3.7.1.1 Seismic Refraction Surveying

Seismic refraction surveying was conducted on December 6 through 8, 1989, in the Airport Area by Weston Geophysical, Corp., as subcontractors to Westinghouse Environmental and Geotechnical Services, Inc.

Seismic refraction surveying consists of measuring the time-of-travel associated with compressional, or "P," seismic waves. The time-of-travel of the seismic waves can be related to the nature, composition, degree of induration, and degree of saturation of the material the waves are traveling through.

The seismic waves are generated by a "shot," or high-velocity acoustic wave generation event, at the "shot point," or the location of the shot. The shot can be generated by various sources such

as air guns, hand-held drop weights, or small explosive charges. The waves are detected by vibration sensitive devices known as geophones. Geophones convert the seismic vibrations, or waves, into electrical signals and transmit those signals to a recording device through dedicated cables.

Interpretations of the geology are made from the analysis of the travel time curves that show the time required for each compressional seismic wave to travel from the shot point to the geophones. In general, velocity ranges of approximately 500 to 6,000 feet per second are indicative of unconsolidated sandy or gravelly materials. The lower velocity range is indicative of unsaturated materials with the seismic velocity range increasing with increasing saturation and density. Seismic velocity ranges of approximately 500 to 8,000 feet per second are indicative of clay units. Seismic velocity ranges of approximately 5,000 to 16,500 feet per second are indicative of consolidated rocks such as sandstone. Bedrock can have seismic velocities that span the entire range from that of unconsolidated sediments upwards, depending upon the type of bedrock and the degree of weathering and/or fracturing.

3.7.1.2 Electromagnetic Terrain Conductivity Surveying

Electromagnetic terrain conductivity (EM) surveying was performed on December 4 through 7, 1989, in the Airport/Klondike Area by Westinghouse. EM uses a transmitter, or coil, to generate a magnetic field. The magnetic field induces eddy currents within the earth. The eddy currents produce secondary electromagnetic fields, which are measured by a receiver coil. The strength of the secondary electromagnetic fields is related to the conductivity of the subsurface materials. The measured conductivity is the weighted cumulative sum of the conductivities from the surface to the effective depth of the instrument. The effective depth of the instrument is a function of the separation of the transmitting and receiving coils.

EM is useful for mapping of shallow conductive bodies, including conductive contaminant plumes, for the detection of buried bulk wastes, and for the detection of buried metal containers, including steel tanks and drums. However, EM is susceptible to interference from powerlines and surficial metals, and lacks vertical resolution compared to DC electrical resistivity methods.

3.7.1.3 Ground Penetrating Radar Surveying

GPR was used on August 6, 1996 in the former Army Barracks Area and on October 15, 1996 in the former Silver Lane Pickle Company Area by Kick Geoexploration. GPR is a geophysical technique based on the transmission and reflection of short, rapid bursts of high frequency radio waves. In practice, a GPR system consists of an integral transmitter and receiver which are dragged on the ground surface along a transect. The transmitting antenna emits electromagnetic



radiation at a frequency between 80 Megahertz (MHz) and 1,000 MHz, depending on the receiving antenna. The receiver records the reflected GPR signal strength. These data can later be transferred to plotting devices for graphic output.

In the subsurface, a portion of the electromagnetic energy is reflected back toward the transmitter when an interface between two materials with differing electrical properties is intercepted. The effectiveness of a buried object as a reflector is a function of the contrast between the electrical properties of the buried object and the sediments. The effectiveness of GPR to identify buried objects is also dependent on the electrical properties of the sediments. In general, conductive media such as silt and clay are effective GPR reflectors and thus limit the effective depth of the GPR signal. Less conductive sediments, such as sand and gravel, are less effective GPR reflectors and the effective depth of GPR signal penetration is much greater.

Interpretation of GPR is typically performed by visual inspection of the form and distribution of the reflected GPR signals. These data are translated into estimates of locations and interpretations of buried objects along the line of the GPR transect. When GPR is used to establish the geometry of the upper surface of a reflecting horizon, a combination of GPR and ground truthing is used to establish points on the reflecting horizon from which interpolations can be based. Ground truthing is the use of established depths, typically derived from borehole data, in conjunction with the GPR results.

3.7.1.4 Magnetometry

Magnetometer surveys were performed by Kick Geoexploration on October 15, 1996 in the former Silver Lane Pickle Company Area. Magnetometry surveying uses a sensitive magnetometer to measure and record anomalies and variations in the prevailing terrestrial magnetic field. The surveying technique uses a detector attached to a staff so that the detector is maintained a constant distance above the earth during the surveying. The detector is attached to a recording device.

In practice, a local base station is chosen where there is minimal variation in the magnetic field intensity, and all measurements are reported relative to the magnetic intensity detected at the base station. During the surveying, magnetic measurements are made and recorded at locations along a predefined grid. These magnetic intensities are then plotted and analyzed to determine the presence of anomalies that may represent buried metallic objects.

3.8 Surveying

Ground surface, top-of-casing (TOC), and top-of-riser (TOR) reference elevations and locations for all water-level measurement points were surveyed to a vertical accuracy of 0.01 feet. Water-level elevations were calculated by subtracting the depth to water from the surveyed reference elevation. The ground surface, TOC, and TOR reference elevations, along with the depth to the top and bottom of the screened interval, for each monitoring well and piezometer are presented in Table 2.

3.9 Analytical Methods and Parameters

Soil samples were submitted to the LEA Analytical Laboratory and analyzed for the presence of target VOCs, including BZ, CBZ, EBZ, PCE, TL, TCA, TCE, and XYL, using a portable gas chromatograph. Analytical parameters for soil samples collected from soil borings installed in the North Parcel were selected on the basis of historical information regarding area-specific operations. Specific contaminants of concern were chosen based on the chemicals and materials known or suspected to have been used in the area and historical information gathered during previous environmental investigations. Specific analyses performed on soil samples, and the rationale for selecting specific samples for analysis are discussed in the appropriate USTMs. The analytical parameters selected for all soil samples are presented in Table 1 of the USTMs. Table 1 presents information regarding which soil samples were submitted for laboratory analyses and whether any of the target analytes for the analyses selected were detected.

Based on the potential contaminants of concern for a particular sampling location, the soil samples were typically submitted for one or more of the following constituents: VOCs by EPA Method 8260B, polychlorinated biphenyls (PCBs) by EPA Method 8082, semivolatile organic compounds (SVOCs) by EPA Method 8270, total petroleum hydrocarbons (TPH) by EPA Method 418.1, and select metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc) by mass analysis and the toxicity characteristic leaching procedure (TCLP) or the synthetic precipitation leaching procedure (SPLP) analysis.

Based on the potential contaminants of concern for a particular sampling location, each of the groundwater samples collected were typically submitted for one or more of the following constituents: VOCs by EPA Method 8260B, PCBs by EPA Method 8082, SVOCs by EPA Method 8270, TPH by EPA Method 418.1, and select metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc)

3.10 Decontamination of Materials and Equipment

The purpose of consistent decontamination procedures was to prevent the potential spread of contamination between boreholes and samples and from the immediate work area around the borehole. All equipment and materials placed into a borehole, or associated with the collection and sampling of soil from a borehole, were decontaminated prior to initiating the drilling activities and between individual samples, as appropriate. Decontamination procedures are presented in the relevant LEA SOPs. Drilling rigs and downhole equipment (e.g., hollow-stem augers, bits, etc.) were decontaminated by steam cleaning prior to initiating any drilling activities at the Airport/Klondike Area. Steam cleaning took place at a decontamination pad. The decontamination pad was typically a portable plastic or metal basin of sufficient volume to hold augers and other drilling equipment that could be laid beneath the back end of the drilling rigs to contain the spent decontamination fluids.

Sampling equipment such as split-spoons and stainless steel spatulas were decontaminated between uses in the field at the drilling site or the decontamination pad. Manual decontamination took place at the drilling site using a portable decontamination system, consisting of small, portable trough to contain over-spray and potentially spilt decontamination fluids, and decontamination solutions in individual 5-gallon buckets, or spray containers, as appropriate. The sampling equipment was decontaminated using the following procedure:

- Brush off gross soil particles.
- Wash and scrub equipment with phosphate-free detergent.
- Rinse equipment with deionized water.
- Rinse equipment with dilute nitric acid solution.
- Rinse equipment in deionized water.
- Rinse equipment with dilute methanol/water solution.
- Rinse equipment in deionized water.
- Allow equipment to air dry.

The decontamination water was maintained in 5-gallon buckets during use, and transferred to 55-gallon drums for disposal. All decontamination fluids were containerized and labeled on-site prior to appropriate storage and disposal. LEA field personnel were responsible for preventing cross-contamination between soil samples collected for laboratory analysis. Sample preparation tables were covered with clean, disposable plastic. Clean, disposable plastic was also laid on the



ground beneath the sample preparation tables and the decontamination solutions to catch dropped soil and spilt decontamination solutions.

3.11 Management of Investigation-Derived Waste

During LEA's portion of the Airport/Klondike Area investigation activities, all soil cuttings brought to the surface during drilling operations, monitoring well development and purge water, and decontamination fluids were placed into appropriate containers, properly labeled, and stored on-site prior to off-site disposal.

All soil cuttings generated during drilling activities were placed in 55-gallon, open-top drums supplied by P&W for subsequent off-site disposal by P&W. The drums were labeled, the sampling locations contributing to each was listed, and the information tracked to aid in waste characterization and disposal.

All spent decontamination fluids generated during drilling activities and purge water generated during monitoring well development activities for the investigation were placed in 55-gallon, closed-top drums supplied by P&W for subsequent off-site disposal by P&W. The drums were labeled, the sampling locations contributing to each was listed, and the information tracked to aid in waste characterization and disposal.



4. SUMMARY OF QA/QC AND DATA MANAGEMENT PROCEDURES

During the course of the subsurface investigation performed at the Airport/Klondike Area by LEA, a significant amount of data was obtained. Geologic, physical, and chemical data were generated during the Airport/Klondike Area investigation. During the performance of field investigation activities, the need to maintain accurate and complete documentation of each phase of the investigation was a paramount concern. Included in this section is a description of the activities undertaken to document, manage, validate, verify, organize, and present the data compiled during the investigation activities performed. This section describes the procedures used to establish quality assurance/quality control (QA/QC) of the data generated during the Airport/Klondike Area investigation activities as well as the procedures, personnel, and software used for inventory, control, storage, verification, and presentation of data.

This section has been organized to present those activities performed by personnel to document the record of investigation activities performed in the field. These discussions are followed by a description of the activities undertaken by personnel in the office to ensure the necessary data have been accumulated, that the data have been properly managed, tracked, validated, verified, entered into the database repository, presented appropriately, and at the conclusion of the investigation, filed for future use.

4.1 Sample Tracking, Collection, Preservation, and Quality Assurance

Field sample tracking activities focused on the timely assignment and tracking of information relevant to field samples collected during the investigation activities. This information included sample identifiers, sample location identifiers, chain-of-custody information, and sample characteristics. Specific sample tracking, collection, and preservation procedures are discussed in greater detail below.

4.1.1 Field Sample Collection Procedures

Three types of field samples were collected as part of the site investigation activities: soil samples, groundwater samples, and soil gas samples. Soil samples were collected for field headspace analysis, close support analytical laboratory analysis and off-site analytical laboratory analysis. Groundwater samples were collected for analysis at an off-site analytical laboratory. Soil gas samples were collected for field analysis with a PID or FID.

Soil samples collected, preserved, and transported for on-site and off-site analytical laboratory analysis were collected in accordance with the procedures described in the LEA SOP for *Soil Sampling*, included in Appendix A. In general, soil samples were collected directly from the



soil-sampling device into the laboratory-supplied sample containers. Soil samples destined for the off-site analytical laboratory were collected into unpreserved jars with Teflon[®]-lined lids, and placed directly into an iced cooler for preservation.

Soil samples intended for analysis at the LEA Analytical Laboratory were collected in accordance with procedures outlined in the LEA SOP for *Soil Sampling* included in Appendix A. Approximately 5 grams of soil was collected into pre-weighed 40-ml glass vials supplied with Teflon[®]-septa, then the vials were filled to 30-ml volume with a pre-preserved sampling water prepared and supplied by the LEA Analytical Laboratory. The actual weight of the samples was recorded to the nearest 0.1 gram.

Groundwater samples were collected, preserved, and transported in accordance with the LEA SOP for *Liquid Sample Collection and Field Analysis* included in Appendix A. Pre-preserved sample containers, appropriate for the specific analyses requested, were supplied by the off-site analytical laboratory. Groundwater samples were collected directly into the sample bottles after purging, and all sample bottles were placed directly into iced coolers for transportation to the off-site analytical laboratory.

4.1.2 Field Sampling Quality Assurance

Several types of QA samples were collected to confirm the reliability and validity of the field data gathered during the Airport/Klondike Area investigation. Duplicate samples were used to provide a measurement of the consistency of samples from the same sampling station and an estimate of variance and bias. Trip and equipment blanks were used to provide an evaluation of potential cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample. Specific QA procedures are discussed in the LEA SOP for *Quality Assurance/Quality Control for Field Activities* included in Appendix A.

4.1.3 Chain-of-Custody

Because samples collected during the Airport/Klondike Area investigation were collected for the purpose of defining the presence or absence of contamination, a traceable sample possession record, from time of collection to analysis, was maintained. Chain-of-custody procedures were used to maintain and document sample possession from collection through analysis. The following documents were used to identify samples and document possession:

- Sample labels
- Chain-of-custody record forms



- Field documentation records

The field sampler was responsible for the care and custody of the samples collected until they were transferred under the appropriate chain-of-custody procedures. Specific chain-of-custody procedures are described in the LEA SOP for *Quality Assurance/Quality Control Measures for Field Activities* included in Appendix A.

4.1.4 Sample Transportation

After collection, all soil and groundwater samples were placed in chilled coolers for transportation to the analytical laboratories. All coolers were kept properly chilled, and under the custody of the sample collection team until the samples were properly transferred to the appropriate analytical laboratory (Accutest, Averill, Lancaster, Quanterra, or the LEA Analytical Laboratory).

4.1.5 Decontamination

All non-disposable sampling equipment, including spatulas, split spoons, Geoprobe[®] MacroCore[™] sampler tubes, and sampler cutting shoes, were decontaminated between uses. Decontamination procedures involved:

- Brush off all contaminated media,
- Wash and scrub with a phosphate-free detergent,
- Rinse equipment with deionized water.
- Rinse equipment with dilute nitric acid solution.
- Rinse equipment in deionized water.
- Rinse equipment with dilute methanol/water solution.
- Rinse equipment in deionized water.
- Allow equipment to air dry.

Spent decontamination fluids were collected into the Department of Transportation (DOT) approved 55-gallon drums at the end of each workday.

4.2 Documentation

During the Airport/Klondike Area investigation, field personnel were responsible for maintaining accurate and complete records of the daily field activities. These records included such information as field activities completed, deviations from planned activities or from

standard practices, information regarding the samples collected, and QA/QC records for equipment and materials used during sample collection. As noted above, the need to maintain accurate and complete documentation of each phase of the Airport/Klondike Area investigation was a paramount concern. As a result, each phase of the investigation was documented in the field, and the field documentation was then reviewed to ensure that all necessary data had been obtained. The following sections describe the documentation procedures performed during the investigation activities conducted at the Airport/Klondike Area.

4.2.1 Survey

Surveying of well and boring locations and selected Airport/Klondike Area features was performed as part of the Airport/Klondike Area investigation process. All survey information was included in the geologic/hydrogeologic database for the Airport/Klondike Area and was used to locate sampling points and other pertinent features on the AutoCAD® drawings that were produced as the base maps for the facility. Information collected as part of the Airport/Klondike Area survey included the location and elevation of on-site monitoring wells and the location of soil borings.

4.2.2 Sample Documentation and Tracking

Samples collected during the investigations were designated using the procedure described in the LEA SOP for *Soil Sampling* included in Appendix A. In general, sample identification information included the following:

- Site location
- Date and time
- Sample matrix
- Sample type
- Sample point number
- Sequential sample number (for multiple depths or times)
- Sample depth interval (where applicable for soil samples)

Field sample tracking activities focused on the timely tracking of information about field samples collected during the Airport/Klondike Area investigation. This information included sampling locations, sample identifiers, chain-of-custody information, sample characteristics, and milestone dates. Such information was transmitted from field to office personnel through the use of daily field summary sheets and other project information tracking forms. Each field team



leader completed daily field summary sheets. The daily field summary sheets detailed the daily activities conducted by the staff, hours logged by staff, problems encountered, general field observations, and samples submitted for analyses. Field summary sheets and project information tracking forms were submitted to the project manager at the end of each working day or as soon thereafter as possible. The summary sheets and forms, in turn, were placed in the central file.

Field sample tracking included the following tasks:

- Assignment of sample identification numbers and other sample identifiers to new samples to be taken, and entry to a tracking system
- Production of sample bottle labels from the tracking system
- Completion of chain-of-custody forms, and entry of this information to the tracking system
- Entry of additional tracking dates to the tracking system
- QA checking of the sample tracking information and processing of change requests
- Production of tracking reports and summary sheets, with distribution to appropriate project staff.

A computer-based sample-tracking system, based on a dBASE® storage and retrieval system, was used for sample tracking.

4.2.3 Daily Field Summary Reports

During the course of the Airport/Klondike Area investigation activities, the field team leader maintained a daily record of events on a daily field summary report. These reports record such items as weather conditions, the status of the daily production, a chronological record of the day's events, problems and problem resolutions, and any departures for the planned events, activities, or standard operating procedures that occurred during the course of the field activities.

During each day of field activities, a record of the events was prepared in the field. This record is referred to as a Daily Field Report and, as appropriate, would include a summary of the daily activities, a field instrumentation and quality assurance record, a field sampling record, chains-of-custody for all samples submitted for analysis, and field-prepared boring logs, well completion logs, or test-pit excavation logs.

In addition, the daily field records include forms that summarize the samples collected, document instrument calibration, and record waste disposition, and document QA/QC procedures. The information collected includes: the sample identifiers; time of collection; type

of sample; depth intervals; the PID/FID headspace measurements; instrument calibration records; source and disposition of decontamination and sampling fluids; and summaries of waste container contents and status.

4.2.4 Field Measurements

Field measurements included physical data (e.g., pH, temperature, specific conductance, depths) collected on the Airport/Klondike Area. Measurements were recorded in the field and transferred manually from the field data sheets contained in the Daily Field Report to the electronic database. The electronic database is described in greater detail in the following parts of this section.

4.2.5 Geologic Information Records

Soil boring and well construction data were included in the geologic/hydrogeologic database for the Airport/Klondike Area. Boring logs include such information as lithology, sample recovery data, drilling method, sample collection information, VOC screening results, and pertinent notes regarding drilling conditions or unusual events.

Soil samples from borings advanced across the Airport/Klondike Area for the purposes of monitoring well installation or evaluating the nature of contamination were classified and logged. The boring log records were entered into an electronic data file. Soil boring logs are the basic form of records for geologic information developed during the field investigation. Geologic boring logs for the soil borings are included in Appendix B.

A monitoring well construction diagram was completed for each monitoring well installed at the Site. The monitoring well construction logs include such information as the screened interval for the well, the types and depths of the filter pack and seals, and the type of wellhead completion installed. Copies of the monitoring well construction logs are included in Appendix D.

4.2.6 Laboratory Analytical Results

Analytical measurements determined using a portable gas chromatograph at the LEA Analytical Laboratory were reported in both hard copy and electronic formats. The electronic formats were transferred to the site electronic analytical database, and the hard-copy reports are printed directly from that database.

All soil samples submitted to a fixed laboratory were typically submitted on "hold." Samples selected for analysis at the off-site laboratory were chosen based upon the results of the field headspace screening, the results of the LEA Analytical Laboratory screening, the nature of the



geologic material as described in the geologic boring logs, and for the analytical requirements for the specific area being sampled. Samples were taken off hold and analyzed by the off-site laboratory on the basis of a sample selection worksheet submitted by the Project Manager.

Accutest, Averill, Lancaster, Quanterra, and the LEA Analytical Laboratory generated off-site analytical measurements. Results from the laboratories were delivered in both hardcopy and electronic formats. The electronic format was provided to the Database Manager for incorporation into the analytical database.

4.2.7 GC/VOC Screening Results

In order to screen soil samples to aid in sample selection and evaluation of contaminant distribution in areas where VOCs were detected, analysis was conducted at the LEA Analytical Laboratory for target VOCs using a portable gas chromatograph.

Soil samples were screened in the field with a portable VOC analyzer for the presence of volatile organic compounds. The results of the field screening provided initial information on the presence of volatile organic compounds in the subsurface. In addition, some soil samples were screened using a portable GC for target VOCs, including BZ, CBZ, EBZ, PCE, TL, TCA, TCE, and XYL, at the LEA Analytical Laboratory.

4.3 Database Management

The electronic analytical database was maintained in the LEA Information Management System (LEA IMS) in a dBASE® format. The database management functions are described in the following paragraphs.

4.3.1 Database Administration

Database administration included coordination of data entry and verification, and review of data for completeness and correctness. The Database Manager interfaced with the Project Manager, field team leaders, and field personnel to ensure that the database met the project objectives.

4.3.2 Electronic Data Entry

Analytical data were verified to assure the accuracy of the electronic, as compared to the hardcopy, analytical laboratory reports. Data verification involved having someone other than the Database Manager manually check a printout from the electronic database against the paper copies of the original laboratory reports. Any deviations from the hardcopies were reported to the Database Manager, and the subsequent changes re-checked to verify their accuracy.



Data received from off-site analytical laboratories in electronic format were checked for completeness by comparing data received with data analyses requested in the chain-of-custody forms. Electronic disks were logged in, checked to see that the files received matched the transmittal paperwork, copied, and archived in the project files.

The electronic data files were downloaded into temporary database files; this download process was conducted by the Database Manager. The downloaded data were loaded into the analytical database and flagged as "not verified" for review by the technical staff.

Results received in electronic format were compared with paper copies of the original laboratory reports. In addition, the sample identification number, location, constituent, and qualifier codes were verified. Upon completion of electronic data verification, the verified files in the electronic database were subjected to the same verification procedures as the unverified electronic data files received from the analytical laboratories.

4.3.3 Archiving of Electronic Data

Archiving of the electronic project database was routinely accomplished. Data were backed up on a no-less-than weekly basis. Data also were backed up at the conclusion of the project. The permanent archive for the analytical and geological/hydrological data is both electronic and hard-copy files maintained by LEA.

4.3.4 Data Verification

An initial review of data obtained from field measurements was performed by the Field Team Leader. This review consisted of checking procedures utilized in the field, ensuring that field measurement instruments were properly calibrated, verifying the accuracy of transcriptions, and comparing data obtained in the field to historic measurements. Field records were subsequently reviewed following completion of each day's field activities for completeness and consistency.

An internal review of analytical data was the responsibility of laboratory personnel. The analyst initiated the data review process by examining and accepting the data. The completed data package was then reviewed by the data reviewer. The data reviewer provided a technical review for accuracy and precision according to the methods employed and laboratory protocols. The data package was also reviewed for completeness (i.e., all pertinent information is included, all appropriate forms are signed and dated, calculations are correct, and holding times and QC sample acceptance criteria have been met). A final review of the data was provided by the Project Manager to ensure that the data package met the project specifications.



4.4 Data Presentation

The objective of data presentation was to illustrate the analytical and geological/hydrogeological data for the Airport/Klondike Area in formats that facilitated data interpretation and visualization. These formats included both tables and figures, as appropriate.

4.4.1 Analytical Data Presentation

Use of the electronic database for storage and retrieval of a wide range of both sample collection and analytical information maximized the ease and accuracy of data review and presentation. Tables of analytical and sampling information were produced in multiple formats to assist in the data evaluation process.

Examples of analytical data presentations incorporated in this report included:

- Tabular listings of analyses conducted sorted by location and sample identification number.
- Summaries of detected values (by area, as appropriate).
- Summaries of exceedances of tabulated numeric criteria in the RSRs.

4.4.2 Facility Maps

Facility maps were created using AutoCAD® software. Base maps were generated using available information from a variety of sources that have been incorporated into the AutoCAD® files.

4.4.3 Graphical Data Display

Graphical data display combined analytical data and/or geological/hydrogeological data with information from the facility base map. Graphical outputs included groundwater contour maps and the areal distribution of contaminant concentrations in soil and groundwater.

4.5 File Organization

Files of original analytical data obtained during this investigation were maintained throughout the investigation and data evaluation process and ultimately archived in a central file. Incoming data were logged into the project file both on the project analytical database and on hardcopy and then were appropriately placed in the file. Analytical results from the laboratories were keyed electronically to the sample identification numbers assigned during sample collection. Original



field documentation forms, paper copies of laboratory reports, and other project files information were transferred from the project file to a designated archive location upon the completion of the project. Computerized data were stored in both hard copy and electronic back-up formats.



5. ENVIRONMENTAL SETTING

This section discusses the overall physical and environmental setting of the Airport/Klondike Area. The Airport/Klondike Area consists of approximately 600 acres. On the northern end of the Airport/Klondike Area is a 75-acre portion (i.e., the Stadium Parcel) that has been offered to the State of Connecticut for the development of a football stadium. This Stadium Parcel is located on the northern end of the Airport/Klondike Area in an area that will be referred to as the North Parcel. This North Parcel includes the Stadium Parcel and areas and environmental units that are immediately adjacent to the Stadium Parcel.

Where appropriate, various physical aspects of the Airport/Klondike Area are discussed in the larger context of the entire East Hartford Main Street main factory complex, the Town of East Hartford, or the entire central Connecticut area. The purpose of presenting the discussion in this manner is to provide a broader background against which to relate the specific physical and environmental characteristics of the Airport/Klondike Area and the North Parcel.

5.1 Physical Setting

The P&W Main Street facility is located at 400 Main Street, East Hartford, Connecticut. The main factory complex, on the western portion of the property, is approximately 4,000 feet east of the Connecticut River, in a mixed residential, commercial, industrial area of East Hartford, Connecticut. In total, the Main Street facility occupies approximately 1,100 acres in the Town of East Hartford. The main factory complex occupies a total of approximately 6.5 million square feet of floor space used for manufacturing, testing, research, office space and space for related activities and support services. At the present time, all activities at the facility take place on the western portion of the property.

To the east of the main factory complex of the Main Street facility lies the Airport/Klondike Area consisting of the Rentschler Airport and an area, known as the Klondike, formerly used for experimental test operations as well as ancillary support operations for the main factory complex. On the northern end of the Airport/Klondike Area is a 75-acre portion (i.e., the Stadium Parcel) that has been offered to the State of Connecticut for the development of a football stadium. This Stadium Parcel is located on the northern end of the Airport/Klondike Area in an area that will be referred to as the North Parcel. This North Parcel includes the Stadium Parcel and areas and environmental units that are immediately adjacent to the Stadium Parcel. This approximately 127-acre North Parcel is the subject area as addresses in this report



The Main Street facility is located in the Central Lowlands physiographic province of Connecticut, a north-south trending valley area between the Eastern and Western Highlands. The area is drained by the Connecticut River and its various tributaries. In this area, the Connecticut River is a tidally influenced river with hydraulic gradients of only a fraction of an inch per mile during low water stages. In the vicinity of the East Hartford facility, important tributaries to the Connecticut River include the Hockanum River, located approximately 0.5 miles north of the facility, Pewterpot Brook that flows through the southeastern portion of the Airport/Klondike Area, and Willow Brook that flows through the northwestern portion of the Airport/Klondike Area.

5.1.1 Meteorological Information

The State of Connecticut is divided into five climatic regions, based primarily upon topography and proximity to Long Island Sound. The Airport/Klondike Area is located in the Central Valley portion of the Northeast climate region of Connecticut. This area has an average annual temperature of approximately 60° Fahrenheit (F), and monthly mean temperatures that range from a low of approximately 36° F in January to a high of approximately 84° F in July. The area receives an average annual precipitation of approximately 44 inches with average monthly precipitation ranging from a low of approximately 3 inches to a high of approximately 4.2 inches. Precipitation tends to be fairly evenly distributed throughout the year in all parts of Connecticut.

The average annual snowfall in the area is approximately 45 inches. Snowfall amounts range between monthly lows of approximately 1 inch to monthly highs of approximately 13 inches. Measurable snowfall amounts are typically recorded between November and April, trace amounts, that is, less than 0.05 inches of snow may be recorded in October and May of any given year. During the months of May through September, wind in the area is generally from the south and averages approximately 7.5 miles per hour. During the months of October through April, wind in the area is generally from the north and averages approximately 9 miles per hour.

5.1.2 Land Use

The property surrounding the Main Street facility is zoned for residential, business and industrial use. The Town of East Hartford Zoning Maps, which were compiled by the Metropolitan District Commission (MDC), show the Main Street facility and the surrounding area. The Main Street facility is zoned Industrial (I-2 and I-3). The areas adjacent to the Main Street facility are zoned Business (B-1) west of the facility along Main Street, Residential (R-3 and R-4) to the south of the facility across Brewer Street, Residential (R-2) to the east of the facility, and



Residential (R-3 and R-4) and Business (B-1A and B-1) to the north of the facility, along and across Silver Lane.

5.1.3 Floodplain Information

The two surface water bodies of importance for floodplain information in the Airport/Klondike Area are: Willow Brook on the northern and northwestern side of the Site near the main facility, and Pewterpot Brook, associated tributaries and wetlands on the southern and eastern part of the Site. Near the main factory complex, the 100-year flood level is 33.3 feet and is located within the Willow Brook pond embankments. The 500-year flood level is 36.1 feet that would also be contained within the pond embankments. Part of the southern portion of the Rentschler Airport and Eastern Klondike Areas are within the 100- and 500-year flood plain.

5.1.4 Wetlands

A wetland survey was conducted in the Airport/Klondike Area by Soil Science and Environmental Services, Inc. of Cheshire, Connecticut, from September 1997 through December 1997. The wetland survey was designed to delineate areas of the Site, which met the criteria for both/either State of Connecticut and/or Federal Wetlands areas. The delineation of the wetland areas involved the delineation of vegetation, the installation of soil test holes to observe soil types and soil moisture conditions, and a review of the Site hydrology.

The State of Connecticut defines wetlands as “land, including submerged land, which consists of any of the soil types designated as poorly drained, very poorly drained, alluvial, and floodplain by the National Cooperative Soils Survey, as may be amended from time to time, of the Natural Resources Conservation Service of the United States Department of Agriculture.”

The Federal government defines wetlands as “those areas that are inundated by surface or groundwater with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflow, mudflats, and natural ponds.”

Based upon the two definitions of wetlands, a total of approximately 32 acres in the North Airport and North Klondike Areas, and 17 acres in the South Airport and South Klondike Areas were directly delineated as areas of wetlands or as watercourses. In addition to the areas defined as wetlands or watercourses, 100-foot buffer zones around each wetland area and 200-foot buffer zones around each watercourse were also defined. These buffer zones are based on the Town of

East Hartford Wetlands Regulations. These buffer zone areas account for an additional approximately 94 acres in the North Airport and North Klondike Areas and an additional 156 acres in the South Airport and South Klondike Areas. The areas of these wetlands/watercourses and their associated buffer zones for the North Parcel are shown on Drawing 1.

5.1.5 Water Supplies

A review of the "Atlas of the Public Water Supply Sources & Drainage Basins of Connecticut" published by the DEP and dated June 1982, identified only two water supplies, both wells, within a 1,000-foot radius of the facility. These two wells, located at the Main Street facility near the main factory complex, were properly abandoned in August 1996 and have not been used since the late 1980s due to low demand.

LEA completed a water service survey in January 1998 confirming that all residences within 550 feet of the Site boundaries were connected to the MDC's public water supply. LEA reviewed the records available at the Town of East Hartford to identify water wells in the vicinity of the Main Street facility. No public or private water wells were found during the record search within a 0.25-mile radius of the facility. A private well was known to exist on a 4-acre residential parcel surrounded by the South Klondike Area (the M^cIlvane Residence, 364 Brewer St., shown on the map as an outlined area near the southern corner of the Airport). P&W installed a connection to the MDC public water supply on January 9, 1998, and abandoned this well on January 21, 1998.

A review of MDC records, which was also undertaken at that time, indicated that the plant and its surroundings are served by the MDC's public water supply. However, a house-to-house survey was not performed to confirm these findings. Sixteen parcels were identified during the survey as inaccessible for inspection and had some form of improvement thereon which was not apparently connected to a public water supply. An update to the water service survey was completed on June 29, 1999 to address these sixteen parcels. The surveys indicated that all parcels studied were either connected to a public water supply or were vacant lots.

Potable water is presently supplied to the facility and greater East Hartford by the MDC of Hartford County. The closest public well fields are located in South Windsor, Manchester and Glastonbury, about 5 to 5.5 miles northeast, east and southeast of the Site, respectively.

5.2 Physiography

The Site has little topographic relief. Ground surface elevations on the Main Street facility range from a high of approximately 55 feet above mean sea level (MSL) in the eastern part of the Klondike Area to a low of approximately 35 feet MSL near the western part of the facility along



Main Street. In general, there is a relatively uniform slope to the land surface from east to west across the Site, however the Airport Area was artificially leveled to provide a suitable airfield.

In addition to the leveling of the ground in the vicinity of the airfield, additional modifications to the natural topography have been made in the dredging and resizing of the unnamed pond in the South Airport Area, the modifications to the eastern unnamed tributary to Pewterpot Brook, and the general development of the Airport/Klondike Area.

5.3 Surface Water Drainage

Surface water runoff on Site is generally toward local surface waters, based on Site topography. Much of the Site shows little topographic relief. The Klondike Area in the eastern portion of the facility ranges from an elevation of about 50 to 60 feet above mean sea level NGVD¹ sloping westward toward the airport at about one percent. The central (airport) portion of the Site is generally flat, with slopes less than 0.5 percent, ranging between an elevation of 38 feet in the southern part to an elevation of 48 feet in the northern part. The main factory complex area generally ranges in elevation from 36 to 40 feet.

The northern portion of the Main Street facility contains Willow Brook and Willow Brook Pond, located north of the main factory complex. Most of the portion of Willow Brook upstream of Willow Brook Pond flows in an underground culvert. A portion in the North Airport Area is open and not in a culvert. Beyond the pond, Willow Brook flows generally westward, and empties into the Connecticut River adjacent to the Colt Street facility.

In the northern and central parts of the Klondike Area, there are unnamed tributaries to Pewterpot Brook, which generally flow in a southerly direction. An underground drainage culvert installed as part of the airport diverts a part of the flow from these streams southwestward under the airport to an unnamed, manmade pond in the South Airport Area. Pewterpot Brook and an unnamed tributary flow in a westerly-southwesterly direction in the southern part of the Rentschler Airport. The southern part of the Rentschler Airport and eastern part of the Klondike Area are within the inland wetland area and associated buffer zone.

5.4 Surface Water and Groundwater Quality

The DEP has adopted water quality classifications for the groundwaters and surface waters of the state to categorize the existing quality of the water, the potential uses of the water, allowable discharges to the water, and the long-term state goals for water quality restoration. Surface

¹ National Geodetic Vertical Datum of 1929



waters and groundwaters are classified separately, and both classification schemes are based on the water quality standards as specified by the DEP.

5.4.1 Surface Water Quality

The surface water classification of the Connecticut River in the area is SC/SB denoting a current surface water quality classification of SC and a surface water quality goal of SB. Class SC surface waters are “those coastal and marine waters defined as suitable for fish, shellfish, and wildlife habitats, certain aquaculture operations, recreational uses, industrial and other legitimate uses and including navigation.” However, a SC designation indicates that one or more Water Quality Criteria are not being consistently achieved. The surface water quality goal for the Connecticut River is SB. Class SB streams are considered “suitable for marine fish, shellfish, and wildlife habitat, shellfish harvesting for transfer to a depuration plant or relay to approved areas for purification prior to human consumption, recreation, industrial and other legitimate uses including navigation.”

Neither Willow Brook nor Pewterpot Brook has received formal surface water classifications by the DEP. Not all surface water bodies within the State have received a classification, often due to a lack of suitable water quality information. When the State has not formally classified a surface water body, according to the provisions of the Water Quality Standards, the surface water quality designations of Willow Brook and Pewterpot Brook default to class A. Class A surface waters are “inland surface waters suitable for recreational use, fish and wildlife habitat, agricultural and industrial water supplies and other legitimate uses including navigation.” Class A streams are also considered suitable for potential drinking water supplies.

5.4.2 Groundwater Quality

The groundwaters beneath the facility have been classified by the DEP as GB. A classification of GB indicates groundwaters within highly urbanized areas or intense industrial activity and where a public water supply is available. The groundwater classification of the Site is based on the map “Adopted Water Classifications for the Connecticut River Basin” prepared by the DEP and dated June 1988. In June 1996, P&W submitted a groundwater reclassification petition to the DEP in order to reclassify the Klondike Area from GA to GB. The petition was subsequently approved in August 1996 by the DEP.

5.5 Regional Geologic and Hydrogeologic Setting

The regional geologic and hydrogeologic setting information presented below provides an overview of the geology and hydrogeology of the greater East Hartford area. This information

has been gathered, primarily by public agencies, from a variety of sources and represents data of varying quality and significance.

5.5.1 Regional Surficial Geology

The P&W Main Street facility lies in the Central Lowlands province of Connecticut, a north-south trending valley system that is approximately 20 miles wide in East Hartford. The lowland consists of a series of parallel valleys separated by linear north-south trending ridges. The Connecticut River flows southward immediately west of the Airport/Klondike Area, draining the northern part of the valley system. The river has created a broad floodplain and eroded terraces in the flatter portion of the valley system.

The unconsolidated sediments in the region were deposited during, and following, the most recent period of glaciation, which ended approximately 10,000 years ago. These materials can be divided into three major units: glacial till and ice-contact stratified sediments, glaciolacustrine deposits, and post-glacial fluvial and eolian deposits. The three units were deposited in the order noted above, with the till and ice-contact sediments generally lying directly over bedrock.

The till is poorly sorted and varies widely from a non-compact mixture of sand, silt, gravel, and cobbles, with trace amounts of clay, to a compact mixture of silt and clay with some sand, gravel, and cobbles. Locally, units consisting of sand and gravel deposited in contact with the ice are present beneath the glaciolacustrine sediments. Glaciolacustrine materials consist of both silt and clay deposited in a glacial lake and sand and gravel deposits formed by beaches and deltas in the lake. These materials may be as much as 270 feet thick in the vicinity of the Airport/Klondike Area.

Post-glacial fluvial sediments consist of sand and silt deposited as the Connecticut River flowed across the exposed deposits of the former lakebed and cut stream terraces into the exposed lacustrine clays and silts. These stream terraces are laterally extensive in the vicinity of the Airport/Klondike Area, and are typically 15 to 30 feet thick. In addition, a thin veneer of eolian (wind-blown) sediments was deposited over parts of the area. These deposits typically consist of yellowish-brown fine- to medium-grained sand and silt. These deposits are only locally important.

5.5.2 Regional Bedrock Geology

The bedrock geology of the region consists of interbedded sedimentary and igneous rocks. The bedrock stratigraphy consists of four sedimentary rock formations: the New Haven Arkose and the Shuttle Meadow Formation, East Berlin Formation, and Portland Arkose, which are

separated by interbedded, laterally continuous basalt flows: the Talcott Basalt; the Holyoke Basalt; and, the Hampden Basalt. These rock units are discussed below in standard geological fashion, from the stratigraphically lowest rock unit to the stratigraphically uppermost unit.

South of the Airport/Klondike Area, in the area of North Haven, Connecticut, the New Haven Arkose is estimated at between 1,950 and 2,250 meters thick. The New Haven Arkose typically consists of alluvial plain sediments deposited by braided streams inferred to have been ephemeral, high-gradient, shallow streams carrying coarse bedloads of pebbly sands. Arkosic rocks typically consist of sand- and gravel-sized particles deposited by rapidly aggrading streams in areas of rapid erosion of igneous or metamorphic uplands. Arkoses are clastic rocks consisting of more than 25 percent feldspar minerals, a majority of quartz, and varying percentages of other, minor constituents. The occasionally cross-bedded arkosic sands of the New Haven Arkose are interbedded with finer-grained typically reddish mudstones indicative of floodplain deposits and are also occasionally capped by caliche deposits indicating a semi-arid depositional environment.

Above the New Haven Arkose is the Talcott Basalt. The Talcott Basalt is a tholeiitic basalt, extruded in between one and four flows, in the north-central and south-central Connecticut, respectively. The thickness of the Talcott Basalt ranges from between 15 to 30 meters in north-central Connecticut and 170 to 330 meters in south-central Connecticut. Basalts are extrusive igneous rocks consisting of minerals such as pyroxenes, olivine, biotite and plagioclase feldspars, with possibly minor amounts of quartz, hornblende, and other minerals. Tholeiitic basalts are typically rich in aluminum and poor in potassium. Because of their extrusive nature, basalts are very fine grained, having cooled and solidified before large mineral crystals could develop.

Above the Talcott Basalt is the Shuttle Meadow Formation. The Shuttle Meadow Formation consists of reddish mudstones, siltstones, and sandstones, interpreted to have been deposited in playa and perennial lake environments based on sedimentological and paleontological evidence. The Shuttle Meadow Formation is approximately 100 meters thick.

Above the Shuttle Meadow Formation is another basaltic lava flow, the Holyoke Basalt. The Holyoke Basalt is similar to the Talcott Basalt previously described. The Holyoke Basalt is typically about 100 meters thick.

Above the East Berlin Formation is the Hampden Basalt. The Hampden Basalt is similar to the Talcott and Holyoke Basalts previously described. The Hampden Basalt is typically about 60 meters thick.

Above the Hampden Basalt is the uppermost unit of sedimentary bedrock, the Portland Arkose. On the western edge of the basin, along the eastern border fault, the Portland Arkose consists of interbedded sandy conglomerate and coarse sandstone deposits, which graded laterally into alluvial plain sequences. The sedimentary units are predominantly composed of interlayered gray or reddish siltstones, sandstones, and conglomerates. The bedrock layers dip to the southeast at approximately 10 to 45 degrees towards the Eastern Border Fault, which is located, approximately 8 to 9 miles east of the Site. The thickness of the Portland Arkose varies from approximately 900 to 1,050 meters in the area of Middletown, Connecticut to over 1,200 meters in the central Connecticut. The original thickness of the Portland Arkose is difficult to determine because of the faulting and erosion that has subsequently altered the upper surface of the unit.

5.5.3 Regional Hydrogeology

The P&W Main Street facility is located within the Upper Connecticut River Regional Drainage Basin. Regional groundwater flow in this part of the basin is expected to be toward the Connecticut River to the west, although local groundwater flow would be controlled by local geologic conditions and anthropogenic features, such as production or basement dewatering wells.

The Connecticut River basin consists of 508 square miles extending from the Massachusetts state line to the northern margin of the Mattabesset River basin at Middletown, Connecticut. The majority of the basin is within the southern part of the Triassic/Jurassic valley, a broad central lowland area flanked by ridges of crystalline rocks on the east and west. Ground elevations within the basin range from approximately mean sea level at the southern boundary to greater than 1,000 feet along the flanking ridges.

Mean annual precipitation is approximately 44 inches. Mean monthly precipitation ranges from 3.0 to 4.2 inches. Mean annual evapotranspiration is approximately 22 inches, with monthly average evapotranspiration rates ranging from 0.2 inches, estimated from above-freezing winter days, to 4.3 inches. Mean annual runoff rate is approximately 22 inches, with monthly runoff rates ranging between 0.9 and 3.6 inches. The net annual storage for the Upper Connecticut River basin is 0 inches. The Connecticut River is tidally influenced throughout a great portion of its reach in Connecticut. Tidal influence determinations were not measured as a part of this investigation.

There are four distinct saturated hydrogeologic units in the shallow subsurface within the region (from uppermost to lowest): (1) glaciolacustrine silt and sand deposits and post-glacial fluvial deposits; (2) glaciolacustrine clay and silt deposits; (3) till and ice-contact stratified sediments; and (4) sedimentary bedrock (the Portland Formation).

The post-glacial fluvial deposits comprise the majority of the upper aquifer and generally constitute the most important aquifer in the region, primarily due to the saturated thickness and extent. The unconfined aquifer is relatively coarse-grained and supplies much of the groundwater used for municipal and industrial purposes in the region.

The majority of the glaciolacustrine deposits are comprised of silt and clay. These sediments have low permeability and function as a confining layer. The glaciolacustrine unit also includes limited sand and gravel lenses and areas of sandy beach and deltaic deposits. These deposits may be locally important as aquifers, but are of limited areal extent.

Glacial till is generally thin and discontinuous, poorly sorted, and contains large amounts of silt and clay, although sandy zones exist. This unit is usually a poor aquifer and is rarely used even for domestic production. Ice-contact stratified sediments beneath the silt and clay layer may be coarse-grained and capable of producing large amounts of water, but these deposits are not laterally extensive and are therefore only locally important.

The Portland Formation consists of southeastward-dipping, well-cemented beds of sandstone and siltstone. Groundwater flow in the bedrock is primarily within fractured and faulted zones. The Portland Formation is an important source of water for domestic use, but yield is generally not sufficient for large-scale users.

5.6 Site Geology

The Airport/Klondike Area geology has been derived from data collected from numerous soil borings, monitoring wells, and water production well logs for locations across the Site, as well as from geologic data derived from other, local test borings and production wells.

5.6.1 Surficial Geology

Post-glaciolacustrine fluvial deposits occur across the Airport/Klondike Area and generally range from 15 to 30 feet in thickness, increasing in thickness toward the central part of the Airport/Klondike Area where greater erosion of the top of the glaciolacustrine silt and clay may have occurred along an ancient channel of the Connecticut River. These deposits generally consist of uniform brown fine or fine to medium sand. Recent laminated silt and sand alluvium occurs near the western boundary of the Airport/Klondike Area along the present course of the Connecticut River. This alluvium is thickest near the Connecticut River and likely interfingers with the older stream terrace deposits. Other recent alluvial deposits are found scattered across the Site near existing and former streams (e.g., Willow Brook) or wetland areas.

Glaciolacustrine lake bottom sediments occur over most of the Airport/Klondike Area and range up to 270 feet in thickness. These deposits thicken towards the central part of the Airport/Klondike Area (near the main factory complex) and are generally absent near the eastern boundary of the Airport/Klondike Area (the Klondike Area). These deposits consist of rhythmically laminated silts and clays with red fine sand partings. The color varies from gray near the surface to red at the base of the unit.

Beneath the eastern portion of the Airport/Klondike Area, the contact between the silt and clay and overlying post-glacial sediments is distinct. However, in the vicinity of the main factory complex, an intermediate layer of fine sand and silt that varies from approximately 5 to 20 feet thick occurs between these two deposits. A similar zone may occur at the base of the glaciolacustrine unit as well.

On-site investigations have indicated that local sand or gravel lenses of glaciofluvial origin are present within the glaciolacustrine unit near its base. However, these lenses do not appear to be laterally extensive.

A layer of glacial till, up to 10 feet thick, is reported to generally directly overlie bedrock beneath the Airport/Klondike Area. However, a gravely sand, ice-contact stratified drift deposit has been documented above or in place of the till in a few isolated instances.

5.6.2 Bedrock Geology

Bedrock beneath the Airport/Klondike Area consists of red sandstones and siltstones of the Portland Formation. Depth to bedrock within the general area is over 300 feet in the area of the main factory complex, and approximately 30 feet along the eastern property boundary in the Klondike Area (except at NK-MW-01 in the eastern portion of the North Klondike Area, where bedrock was encountered at about 12 feet). Near the Connecticut River (west of the Airport/Klondike Area), depth to bedrock is about 150 feet.

A north-south trending buried bedrock valley underlies the main factory complex. This buried valley may have been a pre-glacial channel of the Connecticut River. The presence of this buried bedrock valley has been confirmed by seismic refraction surveys along the airport runway as well as through well logs for deep monitoring and production wells in the Airport/Klondike Area and the local East Hartford area. Because of the presence of this bedrock valley, the local surface of the Portland Formation slopes to the southwest in the Airport/Klondike Area, in contrast to the regional dip of the Portland Formation which is generally to the east at between 10 degrees and 45 degrees; that is, the Portland Formation is revealed as a strike slope in the area beneath the Airport/Klondike Area. Data on the elevation of the bedrock surface were taken



from records of available well logs and test holes installed on the Main Street facility and in the general East Hartford area.

5.7 Site Hydrogeology

The upper zone of the unconsolidated aquifer, which occurs within the stream terrace and glaciolacustrine silt and sand deposits, is the aquifer zone of greatest interest. This is because of the shallow occurrence of economic quantities of groundwater for use, its proximity to potential sources of contamination, and its interconnection with surface water systems. The uppermost zone of this unit is largely composed of well-sorted medium to fine sand, with a saturated thickness generally ranging from 10 to 20 feet. Saturated thicknesses are generally greater towards the center of the Main Street facility where the stream terrace deposits thicken, and less in the eastern portion of the Klondike Area where bedrock approaches the ground surface.

Airport/Klondike Area
The depth to water in the upper zone of the unconsolidated aquifer ranges from approximately 1 to 13 feet below grade. Groundwater flow gradients in this aquifer are quite variable across the Main Street facility, but are generally gentler in the central portion and steeper in the Klondike Area (eastern portion) and adjacent to the Connecticut River (western portion).

The upper aquifer is capable providing large volumes of water as evidenced by the numerous on-site production and dewatering wells. Production wells were installed within or adjacent to the main facility buildings in 1941. Only three of these wells are currently in operation as dewatering wells. Thirteen additional production wells were installed in the South Airport Area and Main Plant Area between 1942 and 1954. Historically, these wells were used as a source of potable water and process water. The wells associated with the well field were reportedly used for process water and taken out of service some time between 1989 and 1994. The abandonment of these wells will occur in the future.

In 1966, the combined yield of these production wells was as high as 850 gallons per minute (gpm). Total pumpage at the plant, including the basement-dewatering network during the most recent water well observation period in the early 1990's, was approximately 535 gpm. During that event, combined yield of the current basement-dewatering network was measured at approximately 235 gpm.

The glaciolacustrine deposits under the Airport/Klondike Area consist almost entirely of lake bottom silt and clay, and are considered to be a confining unit, or aquitard, inhibiting downward flow from the upper aquifer throughout most of the Airport/Klondike Area. This consideration is due to the fact that these sediments are composed of finely-laminated silt and clay which can be



up to 270 feet thick, and are laterally extensive. A slug permeability test conducted in 1990 on a well screened within this unit indicated a horizontal hydraulic conductivity of 2.3×10^{-6} centimeters per second (cm/sec) (6.5×10^{-3} ft/day).

The glacial till and ice-contact stratified sediments form a thin, discontinuous layer directly above the bedrock and, therefore, represent a relatively insignificant hydrogeologic unit. P&W previously operated a production well, which drew water from a gravely deposit overlying bedrock. This well was initially completed in bedrock; however, due to low yield, the bedrock portion of the well was backfilled with sand. This deep overburden well likely withdrew water from an ice-contact stratified drift deposit or from a relatively sandy zone within the glacial till.

The bedrock aquifer is not currently used as a water supply by P&W, although it has been in the past. Three wells were drilled into the bedrock; but only one was used as a bedrock production well. This well was completed in bedrock and yielded approximately 220 gpm on a continual basis from 1939 until about 1966. The portion of this well below the stream terrace deposits was subsequently filled in, when the pump shaft broke within bedrock. The well was then screened within the stream terrace deposits. Limited information is available on water levels or groundwater flow in bedrock beneath the Airport/Klondike Area. Two of these wells were abandoned in August 1996 as discussed previously.

Groundwater flow in the vicinity of the Airport/Klondike Area generally follows the direction of regional flow, westerly to the Connecticut River. However, the local groundwater flow direction may be influenced by various factors. One such factor is the interaction between local surface water bodies and the groundwater system; a second factor is the influence of manmade features (e.g., ditches, ponds, and utilities). Groundwater flow patterns indicate that the local surface water drainage systems, consisting of Willow Brook, Pewterpot Brook, and their respective tributaries, likely act as groundwater discharge points.

Pewterpot Brook and its tributaries drain the majority of the eastern and southern portions of the property. The first tributary, designated the Klondike Tributary by Westinghouse, and designated the East unnamed Tributary to Pewterpot Brook herein, flows within a dug ditch which runs north-south, adjacent to Perimeter Road, parallel to the easternmost runway. The second major tributary to Pewterpot Brook, designated the Suntan Tributary by Westinghouse, and designated the West unnamed Tributary to Pewterpot Brook herein, runs northeast-southwest and crosses the airport in a buried culvert. This tributary emerges from the culvert at a small pond, which was originally excavated in an effort to increase yields for the adjacent Pewterpot Brook Well Field in the South Airport Area.



Previous measurements of baseflow in Pewterpot Brook and its tributaries made by Westinghouse in January 1991 indicated the likelihood that these streams serve as groundwater discharge areas. In the most recent water level data set, surface water elevations were typically lower than nearby groundwater levels, further suggesting that the Pewterpot Brook system serves as a groundwater discharge region. The normal westerly groundwater flow pattern is modified by apparent discharge to the East Unnamed Tributary to Pewterpot Brook and the West Unnamed Tributary to Pewterpot Brook on the western edge of the Klondike. Historically, production wells on both sides of the lower reaches of Suntan Tributary, probably acted to artificially lower local groundwater elevations.

5.7.1 Horizontal Groundwater Flow

The horizontal groundwater flow directions within the upper portion of the aquifer in the Airport/Klondike Area for four events, September 1996, June 1997, November 1997, and April 1998, have been inferred from the water-table elevation measurements.

Gauging data indicate that groundwater flow in the upper aquifer is typically toward the southwest, generally toward the Connecticut River. Local groundwater flow directions across the Site are generally consistent with the expected regional groundwater flow direction, but are locally influenced to varying degrees by the presence of Pewterpot Brook and its tributaries, and the drainage system beneath Rentschler Airport. Pewterpot Brook appears to be generally a gaining stream, receiving groundwater from the upper aquifer over the reach of the stream.

On the November 1997 water-table contour map, the water-table surface appears to be influenced by relatively high groundwater elevations in the North Airport Area near monitoring well NA-MW-03. This area historically has had an elevated water level and the data from this monitoring well is not typically used in constructing water-table contour maps because the water level is typically above the screened interval of the well.

Aside from the somewhat anomalous water-table contour elevations for November 1997, the groundwater elevation contours for the Airport/Klondike Area appear to be temporally uniform. Seasonal variations are typically manifested only in the absolute water-table elevations, however, the relative elevations remain relatively consistent.

5.7.2 Vertical Hydraulic Gradients

Vertical groundwater hydraulic gradients measure the driving force behind vertical groundwater flow within an aquifer or between aquifers. Vertical hydraulic gradients in the Airport/ Klondike



Area have been calculated from groundwater elevation measurements in monitoring well clusters tapping different portions of the upper aquifer. Monitoring well cluster SK-MW-08S/D, in the South Klondike Area and SA-MW-05S/D in the South Airport Area may be used to estimate vertical hydraulic gradients in the upper aquifer.

Vertical hydraulic gradients calculated from water-level measurements made in 1997 indicate that there is a general downward hydraulic gradient to the groundwater in the upper aquifer in the South Airport and South Klondike Areas. Although no data exist for the North Airport and North Klondike Areas, it is reasonable to assume that the same general downward vertical hydraulic gradients exist as observed in the South Airport and South Klondike Areas.

Vertical hydraulic gradients calculated from the March 1990 data indicate a vertical hydraulic gradient of approximately 0.011 feet/foot downward at monitoring wells SK-MW-08S/D. Vertical hydraulic gradients calculated from the November 1991 data indicate a vertical hydraulic gradient of approximately 0.038 feet/foot downward at monitoring wells SK-MW-08S/D. Vertical hydraulic gradients calculated from the June 1997 data indicate a vertical hydraulic gradient of approximately 0.015 feet/foot downward at monitoring wells SK-MW-08S/D and 0.041 feet/foot downward at monitoring wells SA-MW-05S/I. Vertical hydraulic gradients calculated from the November 1997 data indicate a vertical hydraulic gradient of approximately 0.018 feet/foot downward at monitoring wells SK-MW-08S/D and 0.039 feet/foot downward at monitoring wells SA-MW-05S/I.

5.7.3 Hydraulic Conductivity Testing

Hydraulic conductivity testing, in the form of slug/bail testing, has been conducted on various monitoring wells in the Airport/Klondike Area. This testing was conducted in March 1990 on ten monitoring wells in the Airport/Klondike Area by Westinghouse and analyzed by Fuss & O'Neill, Inc. (F&O). The monitoring wells tested were NK-MW-01, NK-MW-04, SA-MW-01, SK-MW-01, SK-MW-02, SK-MW-04, SK-MW-07, SK-MW-08S, SK-MW-08D, and a well identified as CW-2-A, which has not been correlated with an existing monitoring well. Testing was conducted on fifteen additional monitoring wells in December 1991 and January 1992 by H&A. The monitoring wells tested were NA-MW-01, NA-MW-04, NK-MW-03, NK-MW-04, NK-MW-06, SA-MW-01, SA-MW-04, SA-MW-05S, SA-MW-05I, SK-MW-05, SK-MW-08S, SK-MW-10, SK-MW-11, SK-MW-12, and SK-MW-13.

The monitoring wells tested are all in the upper portion of the aquifer, with the exception of monitoring well SK-MW-08D, which is screened within the glaciolacustrine sediments. The results of the hydraulic conductivity testing in the upper portion of the aquifer, generally native and reworked stream terrace deposits, indicated horizontal hydraulic conductivity values of 0.45



to 54 feet/day. These values are consistent with published values for the range of hydraulic conductivity data of 8.2 to 150 feet/day.

The horizontal hydraulic conductivity value for the glaciolacustrine sediments, interpreted from the aquifer testing data from monitoring well SK-MW-08D, was estimated as 0.0066 feet/day. This value is consistent with published values for clay and silt sediments of 0.000001 to 0.1 feet/day.



6. RESULTS OF INVESTIGATIONS

The characterization investigations at the Airport/Klondike Area consisted of environmental setting investigations and contaminant delineation investigations. The environmental setting investigations were designed to refine the Airport/Klondike Area conceptual model and the contaminant delineation investigations were designed to characterize the nature and delineate the extent of soil and groundwater contamination at the Airport/Klondike Area. The environmental setting was discussed in Section 5.

Before the analytical data for soil and groundwater data can be appropriately evaluated relative to the RSRs, it is necessary to first determine that a site has been adequately characterized. This section presents the results of the contaminant delineation phase of the investigation. This section also contains discussions regarding the adequacy of the investigation activities in achieving the goal of adequately characterizing the nature and three-dimensional extent of impacted soil and groundwater within the North Parcel.

The discussion begins with the results of the initial screening investigations followed by the focused soil sampling conducted at each of the environmental units which is then followed by a presentation of the groundwater sampling results. It should be noted that all of the soil sampling results relevant to each environmental unit within the North Parcel are presented in the USTM portion of this report. Specifically, the focused soil sampling results for a given environmental unit will include the results from both the associated contaminant delineation soil borings and the results from borehole sampling performed during groundwater monitoring wells in proximity to that unit. The USTMs also include the relevant groundwater data for a given environmental unit.

6.1 Focused Soil Sampling

As discussed in Section 3, the focused soil sampling portion of the contaminant delineation investigations performed at the Airport/Klondike Area consisted of the collection and analysis of samples of soil and groundwater from sampling points located at the Airport/Klondike Area during the period from 1994 through approximately November 1997. The specific field activities conducted during each of the contaminant delineation investigations for the environmental units are presented in the USTMs.

With the exception of certain select samples, all soil samples collected during the period from 1994 through approximately November 1997 were submitted to the LEA Analytical Laboratory and analyzed for target VOCs. Based upon the results of the field headspace screening, visual or olfactory evidence, and descriptions included in the field sampling records, two soil samples



from each soil boring were typically selected for analysis at the off-site analytical laboratory. Soil samples submitted to the off-site analytical laboratory were analyzed for the suite of analytes particular for each individual environmental unit. The specific suite of analytes for a given environmental unit included a combination of VOCs, SVOCs, target metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc), and TPH. Following the receipt of analysis for target metals at each environmental unit, extractable target metals analyses were requested on selected soils located above the approximate seasonal high water table. Extractable metals were analyzed for in these select soil samples utilizing the TCLP or the SPLP methods.

The analytical data for soils discussed in the following paragraphs are presented in USTMs associated with this report in two formats including: tables presenting a summary of analytical information and detected constituents; and graphical presentations of constituents in soil are provided on maps of the environmental units included as drawings. This section provides general information regarding the particular contaminants identified in soils in the North Parcel and the reported concentrations for those contaminants. More detailed information regarding these contaminants and their spatial distribution is presented in the specific USTMs.

6.2 Results of Soil Investigation

Soil borings were installed in various locations across the North Parcel in the investigation of the specific environmental units present. The locations of the soil borings are presented on Drawing 2. Locations of soil borings were based upon historical information and information obtained from interviews of site personnel and observations of existing site conditions. Soil borings were generally located in areas where current or historical site operations had the potential to cause soil contamination. Soil borings were also located in areas in which visual observation indicated the possibility of soil contamination.

6.2.1 Volatile Organic Compounds

In the North Airport Area, the former Army barracks were occupied from approximately 1942 until 1948. Three soil borings were advanced in the area of the former septic systems associated with these barracks. No VOCs were detected in the soil samples collected.

In the North Airport Area, the former Silver Lane Pickle Company Area includes the areas of the former USTs associated with the pickle company operations, and the soil piles presumably associated with razing of the buildings. VOCs detected in soil samples collected from soil borings installed in this area included: acetone; BZ (screening); carbon disulfide; EBZ; EBZ



(screening); methyl ethyl ketone; methylene chloride; PCE (screening); TL (screening); TCA (screening); TCE; TCE (screening); XYL; and, XYL (screening).

The highest concentrations of VOCs detected in the soil samples collected from the former Silver Lane Pickle Company Area were: acetone, 48J micrograms per kilogram ($\mu\text{g/kg}$); BZ (screening), 30E $\mu\text{g/kg}$; carbon disulfide, 5.9 $\mu\text{g/kg}$; EBZ, 34,000 $\mu\text{g/kg}$; EBZ (screening), 106 $\mu\text{g/kg}$; methyl ethyl ketone, 46 $\mu\text{g/kg}$; methylene chloride, 6.1 $\mu\text{g/kg}$; PCE (screening), 22E $\mu\text{g/kg}$; TL (screening), 31 $\mu\text{g/kg}$; TCA (screening), 260E $\mu\text{g/kg}$; TCE, 19 $\mu\text{g/kg}$; TCE (screening), 2J $\mu\text{g/kg}$; XYL, 120,000 J11 $\mu\text{g/kg}$; and, XYL (screening), 103 $\mu\text{g/kg}$.

In the North Klondike Area, the North Klondike Undeveloped Land Outside Storage Area is located to the northeast of the northern portion of the Klondike Undeveloped Land. The area was used for the storage of materials and equipment, including vehicles. VOCs detected in soil samples collected from soil borings in this area included: acetone; EBZ (screening); methyl ethyl ketone; methylene chloride; PCE; PCE (screening); TL (screening); TCE; TCE (screening); and o-xylene (screening).

The maximum concentrations of the VOCs detected in the soil samples collected from the North Klondike Undeveloped Land Outside Storage Area were: acetone, 290 $\mu\text{g/kg}$; EBZ (screening), 37nc $\mu\text{g/kg}$; methyl ethyl ketone, 15 $\mu\text{g/kg}$; methylene chloride, 46 $\mu\text{g/kg}$; PCE, 380 $\mu\text{g/kg}$; PCE (screening), 111 $\mu\text{g/kg}$; TL (screening), 15E $\mu\text{g/kg}$; TCE, 10 $\mu\text{g/kg}$; TCE (screening), 38 $\mu\text{g/kg}$; and o-xylene (screening), 541nc $\mu\text{g/kg}$.

6.2.2 Semivolatile Organic Compounds

In the North Airport Area, the former Army barracks were occupied from approximately 1942 until 1948. Three soil borings were advanced in the area of the former septic systems associated with these barracks. No SVOCs were detected in the soil samples collected.

The former Silver Lane Pickle Company Area includes the areas of the former USTs associated with the pickle company operations, and the soil piles presumably associated with razing the building. SVOCs detected in soil samples collected from soil borings installed in this area included: benzo[b]fluoranthene; fluoranthene; naphthalene; and, pyrene. The highest concentrations of SVOCs detected in the soil samples collected from the former Silver Lane Pickle Company Area were: benzo[b]fluoranthene, 600 $\mu\text{g/kg}$; fluoranthene, 700 $\mu\text{g/kg}$; naphthalene, 1,600 $\mu\text{g/kg}$; and, pyrene, 680 $\mu\text{g/kg}$.

In the North Klondike Area, the North Klondike Undeveloped Land Outside Storage Area is located to the northeast of the northern portion of the Klondike Undeveloped Land. The area



was used for the storage of materials and equipment, including vehicles. The only SVOC detected in soil samples collected from soil borings in this area was 2-methylnaphthalene. The maximum concentrations of the 2-methylnaphthalene detected in the soil samples collected from the North Klondike Undeveloped Land Outside Storage Area was 2,900 µg/kg.

6.2.3 Total Petroleum Hydrocarbons

In the North Airport Area, the former Army barracks were occupied from approximately 1942 until 1948. Three soil borings were advanced in the area of the former septic systems associated with these barracks. No TPH was detected in the soil samples collected.

The former Silver Lane Pickle Company Area includes the areas of the former USTs associated with the pickle company operations, and the soil piles presumably associated with the razing of the buildings. TPH were detected in soil samples collected in this area at a maximum concentration of 10,500 milligrams per kilogram (mg/kg).

In the North Klondike Area, the North Klondike Undeveloped Land Outside Storage Area is located to the northeast of the northern portion of the Klondike Undeveloped Land. The area was used for the storage of materials and equipment, including vehicles. TPH were detected in soil samples collected in this area at a maximum concentration of 13,000 mg/kg.

6.2.4 Metals

Metals, at various concentrations, are ubiquitous in soils. Site-specific background concentrations can be developed if undisturbed areas of the site can be identified and sampled. Specific background areas of the Airport/Klondike Area were identified as a part of this investigation. A complete discussion of the background metals is included as *Technical Memorandum Number 4 Background Soil Sampling and Analysis* in Appendix E.

In the North Airport Area, the former Army barracks were occupied from approximately 1942 until 1948. Three soil borings were advanced in the area of the former septic systems associated with these barracks. Metals detected in soil samples collected in this area included: arsenic; barium; cadmium; chromium; copper; nickel, and, zinc. The highest concentrations of metals detected in soil samples collected in the former Army Barracks Area were: arsenic, 3.53 mg/kg; barium, 153 mg/kg; cadmium, 4.43 mg/kg; chromium, 29.5 mg/kg; copper, 24.3 mg/kg; nickel, 26.2 mg/kg; and, zinc, 87.5 mg/kg.

The former Silver Lane Pickle Company Area includes the areas of the former USTs associated with the pickle company operations, and the soil piles presumably associated with razing the building. Metals detected in soil samples collected in this area included: arsenic; barium;



cadmium; chromium; lead; mercury; nickel; selenium; silver; and, zinc. The highest concentrations of metals detected in soil samples collected in the former Silver Lane Pickle Company Area were: arsenic, 37.2 mg/kg; barium, 1370 mg/kg; cadmium, 5.84 mg/kg; chromium, 217 mg/kg; lead, 5,020 mg/kg; mercury, 0.896 mg/kg; nickel, 74.5 mg/kg; selenium, 5.7 mg/kg; silver, 20 mg/kg; and, zinc, 3,430 mg/kg.

In the North Klondike Area, the North Klondike Undeveloped Land Outside Storage Area is located to the northeast of the north Klondike Undeveloped Land. The area was used for the storage of materials and equipment, including vehicles. The metals detected in soil samples collected from soil borings in this area included: arsenic; barium; chromium; lead, and, zinc. The maximum concentrations of the metals detected in the soil samples collected from the North Klondike Undeveloped Land Outside Storage Area were: arsenic, 3.87 mg/kg; barium, 40.5 mg/kg; chromium, 10 mg/kg; lead, 36.8 mg/kg; and, zinc, 49.4 mg/kg.

6.2.5 Polychlorinated Biphenyls

In the North Klondike Area, the North Klondike Undeveloped Land Outside Storage Area is located to the northeast of the north Klondike Undeveloped Land. The area was used for the storage of materials and equipment, including vehicles. The only PCB detected in soil samples collected from soil borings advanced in the vicinity of this unit was Aroclor 1260 at a maximum concentration of 61J µg/kg.

6.3 Results of Soil Vapor Surveying

The soil vapor survey performed in the former Silver Lane Pickle Company Area in the North Airport Area was conducted on a qualitative basis, to determine the potential presence of contaminants in the subsurface resulting from the former underground storage tanks reported to have been used by the pickle company operations and to direct additional focused soil boring investigations in the area. The results of this soil vapor survey are presented in the Silver Lane Pickle Company USTM.

6.4 Results of Groundwater Investigation

This section provides general information regarding the particular contaminants identified in groundwater in the Airport/Klondike Area and the reported concentrations for those contaminants. More detailed information regarding these contaminants and their spatial distribution is presented in the specific USTMs. The locations of the monitoring wells are presented on Drawing 4.



6.4.1 Water Table Contour Maps

A water table contour map was generated from gauging data generated during the groundwater-sampling event at the Airport/Klondike Area in June 1997. Water table contours are based on surveyed elevations of monitoring well reference points and depth to water measurements. A water table contour map for June 1997 is presented on Drawing 4.

Water table elevation gauging data for additional gauging events is also included on this drawing. The water table contour map indicates that the direction of groundwater flow beneath the Airport/Klondike Area is generally from northeast to southwest over the majority of the Airport/Klondike Area, but from the south to the north on the eastern portion of the Airport/Klondike Area.

Groundwater investigations were completed as part of an overall evaluation of groundwater quality and as ancillary aspect of the focused soil investigation program. Because of the general nature of groundwater, the contaminant delineation investigation was evaluated on an area-wide rather than a unit-specific basis.

6.4.2 Volatile Organic Compounds

In the North Airport Area and the North Klondike Area, no VOCs were detected in groundwater samples collected during the latest round of groundwater sampling in November 1997.

6.4.3 Semivolatile Organic Compounds

In the North Airport Area, SVOCs detected included benzo[b]fluoranthene at a concentration of 1.2 microgram per liter ($\mu\text{g/l}$) in the groundwater sample collected from soil boring NA-SB-57.

6.4.4 Total Petroleum Hydrocarbons

In the North Airport Area, TPH was detected in groundwater samples at concentrations between 2.6 and 4.4 mg/l in the groundwater samples collected from soil borings NA-SB-21 and NA-SB-06, respectively.

6.4.5 Metals

In the North Airport Area, metals detected in groundwater samples collected from soil borings and monitoring wells in the North Airport Area included barium, cadmium, and zinc. Some of these metals (particularly barium and zinc) are naturally occurring in groundwater. Cadmium was detected in the North Airport at two groundwater-sampling locations (NA-SB-09 at 0.202 milligrams per liter (mg/l), and NA-SB-29 at 0.0031 mg/l).



Barium and zinc are ubiquitous at low concentrations in the groundwater throughout the North Airport Area. These metals are present at low concentrations (barium was detected at concentrations between 0.010 mg/l and 0.797 mg/l, and was typically present below 0.3 mg/l; zinc was detected at concentrations between 0.11 mg/l and 0.641 mg/l, and was typically present at concentrations below 0.1 mg/l). The low concentration ranges of barium and zinc, and the widespread nature of their occurrence suggests that these two metals are natural groundwater constituents.

Metals detected in groundwater samples collected from soil borings and monitoring wells in the North Klondike Area include arsenic, barium, cadmium, chromium, lead, nickel, and zinc. Some of these metals (particularly barium and zinc) are naturally occurring in groundwater. Arsenic was detected in one groundwater sample in the North Klondike Area at concentrations of 0.0051 mg/l (NK-MW-17). Nickel was detected in several soil borings and monitoring wells in the North Klondike (NK-MW-17 at 0.0412 mg/l).

Barium and zinc are ubiquitous at low concentrations in the groundwater throughout the North Klondike Area. These metals are present at low concentrations (barium was detected at concentrations between 0.010 mg/l and 0.797 mg/l, and was typically present below 0.3 mg/l; zinc was detected at concentrations between 0.11 mg/l and 0.641 mg/l, and was typically present at concentrations below 0.1 mg/l). The low concentration ranges of barium and zinc, and the widespread nature of their occurrence suggests that these two metals are natural groundwater constituents.

6.4.6 Polychlorinated Biphenyls

There were no PCBs were detected in groundwater in either the North Airport Area or the North Klondike Area.

6.5 Geophysical Survey Results

The results for the geophysical surveys conducted at the Airport/Klondike Area are presented below.

6.5.1 Seismic Refraction Survey

A total of 7,190 foot seismic refraction line was profiled along the eastern edge of the airport runway on December 6 through 8, 1989. Based on overlapping geophone spreads, data sets from multiple seismic profiles were analyzed and correlated. An analysis of the seismic refraction data, based on seismic velocity only, was performed to characterize the thickness of the unconsolidated materials. Topographic elevation data from survey data and airport drainage



plans was used to provide surface elevation data along the seismic line (Weston Geophysical Corp., 1990).

The seismic velocity data was separated into three groups, based on the relative degree of induration, the degree of saturation, and the composition of the materials present. The relatively loose, unconsolidated, unsaturated surficial materials had seismic velocities of 1,200 to 1,600 feet per second. Seismic velocities in this range are consistent with a variety of unsaturated sediments. These unsaturated materials, interpreted to be stream terrace deposits, were between 10 to 4 feet thick: thickest in the southwestern portion of the runway, where the water table is deepest, and gradually thinning toward the northeast.

Beneath the unsaturated materials was a layer characterized by intermediate seismic velocities of 4,850 to 4,900 feet per second. Seismic velocities in this range would be characteristic of saturated or clay-rich materials. This zone was interpreted to be saturated stream terrace deposits and glaciolacustrine sediments. These materials were interpreted as continuing to bedrock.

Beneath the zone of intermediate seismic velocities was a zone with seismic velocities approximately between 12,500 to 13,200 feet per second. This zone was interpreted to be bedrock. Seismic velocities in this range are consistent with those for sound sandstone or shale. These materials were not found to be of a defined thickness, that is, there was no additional underlying rock layer noted within the depth range of the seismic energy wave.

The bedrock surface, as interpreted from the seismic refraction profile, is approximately 277 feet deep in the southwest end area of the runway. The bedrock surface rises to a depth of approximately 135 feet within the first 3,000 feet from the southwest end area of the runway. Over the course of the next 4,190 feet of the seismic profile, the bedrock surface rises to a depth of 81 feet below the ground surface. The bedrock surface interpreted from these data is consistent with bedrock elevation data interpolated from test boring and production well logs for the East Hartford area.

There was no indication of a weathered or highly fractured zone in the upper portion of the bedrock. In addition, because of the range of seismic velocities observed, it was not possible to determine whether a zone of glacial till or stratified drift was present beneath the glaciolacustrine sediments.

6.5.2 Electromagnetic Terrain Conductivity Survey

EM surveys were conducted along eleven transects in the Airport/Klondike Area on December 4 through 7, 1989. During the survey, terrain conductivity measurements were recorded every 100



feet along the established survey lines. Also, measurements were continuously monitored so that conductivity anomalies could be identified.

The first terrain conductivity survey was conducted along the airport runway, along the same transect used for the seismic refraction survey. During the survey, a number of anomalies were recorded. With the exception of three, all of these anomalies were associated with subsurface conduits having surface expressions or being otherwise traceable. The three remaining anomalies were thought to be due to conduits, possibly drain pipes, which lacked surface expressions or could not otherwise be traced.

Two terrain conductivity survey lines were conducted in the North Klondike fill piles. Three conductivity anomalies were recorded from known sources, including two buried conduits and surficial steel drums. An additional oval-shaped anomaly, approximately 11 by 25 feet, was also noted to the west of the profile lines.

6.5.3 Ground Penetrating Radar Survey

A total of sixteen GPR transects were performed in the North Airport Area on August 6, 1996, to determine the presence and location of septic systems associated with the former Army Barracks Septic Systems. In general, the location of the former septic system tanks and associated piping were located based on the interpretation of the GPR signals. In addition, "cell" structures, apparently related to the former septic systems were also located. Based upon an interpretation of the GPR signals, these cell structures appear to be composed of columns of undisturbed native materials separated by areas of homogenous fill material.

Possible former septic system tanks associated with the former 150-man and 100-man latrines, former supply and administration building, and former operations building, were located. Cell structures associated with the former septic systems of the 100-man and 150-man latrines, former supply and administration building, and the former leach fields associated with the 100-man and 160-man latrines were located. Various potential pipes were located throughout the area surveyed.

A total of three individual GPR surveys were conducted in the former Silver Lane Pickle Company Area. All of the surveys were performed to determine the presence of buried tanks in the area. At the southwestern corner of the area a prominent cylindrical object at a depth of 4 to 5 feet was detected and interpreted to be a large pipe. In the remaining two areas various objects were detected, but no reflections characteristic of a buried tank were interpreted from the results.



The results of magnetic surveying conducted in this area, discussed below, were generally consistent with these interpretations. However, the magnetic survey indicated the possible presence of buried tank in the northeastern corner of the area. There was no indication of a buried tank in the GPR survey results.

6.5.4 Magnetometry Survey

The three areas previously discussed under GPR survey results were also surveyed magnetically. The magnetic surveying results indicated a magnetic anomaly in the area of the southwestern corner of the area, consistent with a large pipe at a depth of 4 to 5 feet, and the possible presence of a buried tank in the northeastern corner of the area. GPR survey data did not indicate the presence of a buried tank, however. An additional magnetic survey was conducted along the soil piles located in this area. No significant magnetic anomalies were noted during this survey.



7. EVALUATION OF THE RESULTS AGAINST THE RSRs

This section provides a comparison of the analytical data from soil and groundwater collected at the North Parcel to the criteria established pursuant to the RCSA Section 22a-133k-1 through 22a-133k-3, also referred to herein as the DEP RSRs. Data discussed in this section include that data collected in the North Parcel.

7.1 Evaluation Process

Before performing a final evaluation of the analytical data to determine whether or not a Site is in compliance with the Connecticut RSRs, it is necessary to demonstrate that the investigation performed was adequate to identify potential release areas at the site and to characterize the nature and extent of any contamination associated with those release areas. For the site characterization investigations, this evaluation includes an evaluation of the locations and depths at which the release would have likely occurred, sampling locations and depths relative to potential release areas, and potential contaminant transport pathways. It is also necessary to evaluate whether or not the appropriate media were sampled and whether analyses performed on samples of various media were appropriate for detection and delineation of potential releases of constituents of concern at the Site.

After determining that the subsurface investigation was adequate and that the sampling and analyses were representative of site conditions, the next step in the evaluation process is to compare data from the site to the tabulated numeric criteria presented in the RSRs. Tabulated numeric criteria for individual constituents are media-specific, and comparison to more than one set of criteria for both soil and groundwater is required. Only if concentrations detected in soil and/or groundwater at the Site exceed the numeric criteria is further evaluation relative to the RSRs warranted. The applicable numeric criteria against which soil and groundwater data were evaluated were those criteria that have been specifically tabulated in Appendices A through E of the RSRs. For constituents that do not have a tabulated numeric criteria, calculated criteria must be developed in accordance with the RSRs.

Based on a review of the nature and location of historical activities that have occurred at the North Parcel and the potential contaminants anticipated based on those activities, the subsurface investigations performed at the North Parcel resulted in adequate characterization of the nature of contamination present. The investigation was also adequate to delineate the extent of contamination in specific areas. With respect to specific cases, such as areas of that were proposed for remediation through excavation, it was assumed that additional delineation was necessary and would be accomplished as part of the future remediation.



The following sections include evaluations of the site-specific data relative to the RSRs. The evaluation is presented by media and includes a comparison to all relevant criteria for each medium and the site-specific conditions. Soil data are compared to tabulated numeric residential direct exposure criteria (RDEC) and the GB pollutant mobility criteria (GBPMC) for each of the constituents detected. The RSRs require groundwater within a “GB” groundwater quality area to be remediated to protect existing uses; additionally, groundwater plumes which discharge to a surface water body must meet the surface water protection criteria (SWPC). Groundwater within 15 feet of the surface must also meet the volatilization criteria of the RSRs. Consequently, concentrations of constituents detected in groundwater are compared to the SWPC, and the residential volatilization criteria (RVC).

7.2 Evaluation of Soil Data

In order to evaluate compliance with the direct exposure criteria, concentrations of organic constituents and total metals detected in soil were initially compared to the tabulated RDEC presented in the RSRs. Similarly, compliance with the GBPMC for organic compounds is demonstrated by initially comparing detected concentrations with the tabulated GBPMC. However, for metals, compliance with GBPMC is demonstrated by comparing the concentrations of metals in the extract of soils subjected to the SPLP or TCLP. The SPLP procedure was designed to simulate the leaching potential of natural precipitation, while the TCLP procedure was designed to simulate the leaching potential of landfill leachate.

As an alternative to performing a TCLP or SPLP extraction on all soil samples, compliance with the PMC for metals can be demonstrated by multiplying the tabulated PMC values by a factor of 20 (which accounts for dilution during the extraction process) and comparing those values to the concentrations detected during mass analysis. This method assumes that all the metal in the soil sample would leach out during the extraction procedure, and is, therefore, a worse case estimate of the actual amount that might leach. If the concentration detected following mass analysis for total metals is less than the calculated worst-case value, then compliance is achieved.

This section provides general information regarding the particular contaminants and exceedances identified in soils in the North Parcel and the reported concentrations for those contaminants. More detailed information regarding these contaminants and their spatial distribution is presented in the specific USTMs.



7.2.1 Direct Exposure Criteria

To avoid the need for an Environmental Land Use Restriction (ELUR) at the Site, the RDEC must be met. To satisfy the RDEC, soils within fifteen feet of the ground surface must exhibit contaminant concentrations lower than the applicable criteria.

For the Silver Lane Pickle Company Area, the data were compared against the default numeric criteria included in the RSRs and the site-wide background soil concentrations for metals. The concentrations of some of the metals detected in the soil samples are not typical of background concentrations. Higher than background concentrations of barium, chromium, lead, and zinc were detected in several soil samples from borings NA-SB-30, NA-SB-36, NA-SB-38, NA-SB-41, NA-SB-42, NA-SB-45, and NA-SB-49. In addition, the lead concentration detected in borings NA-SB-42, NA-SB-45 and NA-SB-49 exceeded the tabulated RDEC and IDEC. Arsenic was detected in borings NA-SB-45 and NA-SB-49 at concentrations that exceed the RDEC and IDEC. For TPH detected exceedances of the RDEC and the IDEC were noted in borings NA-SB-41, NA-SB-42, and NA-SB-49. In addition, the concentration of TPH in boring NA-SB-48 at a depth of 2 to 4 feet exceeds the RDEC.

For the North Klondike Undeveloped Land Outside Storage Area, the concentrations of TPH detected were above the RDEC in the soil borings NK-SB-21, NK-SB-310 through NK-SB-314, NK-SB-322 through NK-SB-323, NK-SB-325 and NK-SB-326 at varying depth, ranging from 0 to 10 feet. Also, the concentrations of TPH detected in soil borings NK-SB-310 through NK-SB-311 were above the IDEC and the GBPMC. The concentration of TPH detected in test pit sample NK-TP-04N was above the RDEC.

7.2.2 GB Pollutant Mobility Criteria

The pollutant mobility criteria of the RSRs are designed to protect groundwater from contaminants that may leach from soils during infiltration events. To satisfy the pollutant mobility criteria in a GB groundwater classification area, concentrations of substances in soil above the seasonal high water table must not exceed the pollutant mobility criteria applicable to GB areas.

For the Silver Lane Pickle Company Area, the data were compared against the tabulated numeric criteria included in the RSRs. For TPH detected exceedances of the GBPMC were noted in borings NA-SB-41, NA-SB-42, and NA-SB-49.

For the North Klondike Undeveloped Land Outside Storage Area, TPH was detected in soil borings NK-SB-310 through NK-SB-311 above the GBPMC.



7.3 Evaluation of Groundwater Data

The criteria established in the RSRs for groundwater are designed to protect existing uses of groundwater, surface water quality where groundwater plumes discharge into those water bodies, and air quality from the effects of vapors emanating from VOCs present in contaminated groundwater. For areas where the groundwater has been classified as GA, the groundwater protection criteria provided in the RSRs were developed to protect groundwater quality in those areas in order to maintain the existing classification which allows for direct consumption of the groundwater without the need for treatment. In GB groundwater quality areas, the groundwater protection aspect of the RSRs is designed to preserve water quality to permit the existing uses of groundwater and prevent further degradation of groundwater quality. No specific tabulated groundwater protection criteria exist for groundwater in GB areas.

Surface water protection and volatilization criteria apply to groundwater, regardless of the classification. Surface water protection criteria apply if the groundwater discharges to a surface water body, and volatilization criteria apply to groundwater within fifteen feet of the ground surface or a building. Consequently, groundwater data collected during the subsurface investigations conducted at the Site have been compared to tabulated numeric criteria presented in the RSRs for surface water protection, and shallow groundwater quality was compared to tabulated volatilization criteria provided in the RSRs.

This section provides general information regarding the particular contaminants and exceedances identified in groundwater in the North Parcel and the reported concentrations for those contaminants. More detailed information regarding these contaminants and their spatial distribution is presented in the specific USTMs.

7.3.1 Surface Water Protection Criteria

In the Silver Lane Pickle Company Area, several exceedances of the SWPC were noted for metals detected in groundwater. However, additional groundwater data from borings NA-SB-50 through NA-SB-54 indicate that the zinc concentrations from borings NA-SB-29 and NA-SB-38 do not exceed the RSRs and the SWPC is not applicable. The zinc emanating from borings NA-SB-29 and NA-SB-38 do not discharge directly to the brook at a concentration that exceeds the SWPC. Groundwater samples from NA-SB-50 through NA-SB-53, located between the brook and borings NA-SB-29 and NA-SB-38, have concentrations of zinc below the SWPC. These downgradient compliance points do not indicate an exceedance of the SWPC.



7.3.2 Residential Volatilization Criteria

The RVC of the RSRs apply to groundwater within fifteen feet of the ground surface or a building. The RVC are designed to address the potential for VOCs volatilized from groundwater to migrate through the unsaturated zone to indoor air. No exceedances of the RVC were noted for the constituents detected in groundwater at the North Parcel.



8. REMEDIAL ACTIVITIES

This section discusses the remedial activities conducted at the North Parcel between November 1998 and the present time. Remedial activities were conducted to remove contaminated soil from areas within the North Parcel. Soil removals were conducted in the Silver Lane Pickle Company Area and the North Klondike Undeveloped Land Outside Storage Area. This section provides general information regarding the particular contaminants identified in soils in the North Parcel and the remediation activities undertaken to address those contaminants. More detailed information regarding these contaminants, their spatial distribution, and the remedial activities is presented in the specific USTMs.

In general, soil remediation was conducted by removal of the soil to a depth below or beyond that anticipated to be contaminated. Upon removal of the impacted soil, confirmational sampling was conducted to confirm that all contaminated soil was excavated prior to backfilling the area. During excavation, all soil excavated was placed directly into dump trucks for off site disposal.

To avoid the need for an ELUR at the Site, and in accordance with Section 22a-133k-2(b) of the RSRs, the RDEC must be met. To satisfy the RDEC, soils within 15 feet of the ground surface must exhibit contaminant concentrations lower than the applicable criteria. Whenever feasible, the soil removal was performed to a point where the remaining levels were below RDEC. In cases where a significant volume of material was present that exceeded the RDEC or in cases of exceedances of the IDEC, the goal of the removal activity was to remove the exceedances within 4 feet of the ground surface. Soil with contaminant concentrations above the DEC within four feet of the ground surface was excavated along with the use of an ELUR for soils below 4 feet for the area to satisfy the criteria for inaccessible soil. Also, to satisfy the pollutant mobility criteria in a GB groundwater classification area, concentrations of substances in soil above the seasonal high water table that exceeded the pollutant mobility criteria applicable to GB areas were excavated.

8.1 Silver Lane Pickle Company Area

On November 12 and 13, 1998, four test pits, NA-TP-20 through NA-TP-24, were advanced as part of soil removal activities in the area. The test pits were located relative to the existing borings where VOCs, metals, and TPH were previously detected. Soil with contaminant concentrations above the DEC within four feet of the ground surface was excavated. Test pit locations and sizes are shown on Drawing 3. After these quantities of soil were removed, confirmational samples of the excavation sidewalls and bottoms were collected to confirm the removal of the material.



During the excavation of NA-TP-20 a crushed steel tank, approximately 500 gallons, miscellaneous piping, bottles, and other assorted debris were unearthed. During the excavation of test pit NA-TP-20, olfactory evidence of contamination and soil staining were also noted. Groundwater was encountered in this excavation at a depth of approximately 6 feet. During the excavation of NA-TP-21 a section of 2-inch ductile pipe and a section of 1-inch electrical conduit were unearthed. During the excavation of NA-TP-24 a steel tank was unearthed. The tank appeared to have been opened previously and was filled with sand. Soil staining and a strong evidence of olfactory contamination were also noted in the soil from this excavation.

Based on the confirmational sampling conducted, two test pits, NA-TP-20 and NA-TP-24, were over-excavated on March 25, 1999 as part of soil removal activities in the area. These excavations were located relative to the existing confirmational samples where VOCs and metals were previously detected. The over excavation of the sidewalls included stepping sidewalls out 4 feet, extending the lateral extent from clean sample to clean sample, and matching the original excavation depth. The over excavation for the bottoms included increasing the depths up to 4 feet and extending the lateral extent from clean sample to clean sample.

During the excavation of NA-TP-20, miscellaneous piping, bottles, and other assorted debris were unearthed. During the excavation of test pit NA-TP-20 olfactory evidence of contamination and soil staining were also noted. During the over excavation of NA-TP-24, soil staining and a strong evidence of olfactory contamination were also noted in the soil from this excavation.

Based on the confirmational sampling conducted, one test pit, NA-TP-20 was over-excavated on June 17, 1999 as part of soil removal activities in the area. These excavations were located relative to the existing confirmational samples where metals were previously detected. The over excavation for the sidewalls included stepping sidewalls out 4 feet, extending the lateral extent from clean sample to clean sample, and matching the original excavation depth. Upon receipt of the confirmational sample results, the area was backfilled and compacted.

With the completion of the soil removal activities for this area, soils with contaminant concentrations above the DEC within four feet of the ground surface have been excavated. For the remaining soils, an ELUR for soils below four feet will be necessary for the area to satisfy the IDEC criteria for inaccessible soil.

8.2 North Klondike Undeveloped Land Outside Storage Area

On December 1, 1998, one test pit, NK-TP-20, was advanced as part of soil removal activities in the area. The test pit was located relative to the existing borings where VOCs and TPH were



previously detected. Soil with contaminant concentrations above the DEC within eight feet of the ground surface was excavated. The test pit location and size is shown on Drawing 1. After these quantities of soil were removed, confirmational samples of the excavation sidewalls were collected to confirm the removal of the material.

On March 25, 1999 and April 19, 2000, one test pit, NK-TP-20, was over-excavated as part of soil removal activities in the area. These excavations were located relative to the existing confirmational samples where TPH and SVOCs were previously detected. The over excavation protocol for sidewalls included stepping sidewalls out 4 feet, extending the lateral extent from clean sample to clean sample, and matching the original excavation depth. Test pit locations and over excavations are shown on Drawing 3. After these quantities of soil were removed, confirmational samples of the excavation sidewalls and bottoms were collected to confirm the removal of the material. Upon receipt of the confirmational sample results, the area was backfilled and compacted.

With the completion of the soil removal activities for this area, soils with contaminant concentrations above the DEC within eight feet of the ground surface have been excavated. For the remaining soils, an ELUR for soils below eight feet will be necessary for the area to satisfy the IDEC criteria for inaccessible soil.

8.3 Post-Remediation Monitoring

In accordance with Section 22a-133k-3(g)(2)(A), post-remediation groundwater monitoring must be performed to confirm the effectiveness of the soil remediation in eliminating a source of contaminants to groundwater in the release areas. The monitoring program will consist of the several monitoring wells located in the North Parcel. Groundwater will be monitored for those contaminants that resulted in soil remediation in the corresponding areas as well as metals that have also been identified previously. Upon completion of the remediation, the length of the monitoring program is two years for a GB area as stated in Section 22a-133k-3(g)(3)(A)(iii) of the RSRs.



9. SUMMARY AND CONCLUSIONS

9.1 Summary of Background Information

To the east of the main factory complex of the Main Street facility lies the approximately 600-acre Airport/Klondike Area consisting of the Rentschler Airport and an area, known as the Klondike, formerly used for experimental test operations as well as ancillary support operations for the main factory complex. On the northern end of the Airport/Klondike Area is a 75-acre portion (i.e., the Stadium Parcel) that has been offered to the State of Connecticut for the development of a football stadium. This Stadium Parcel is located on the northern end of the Airport/Klondike Area within an area that will be referred to as the North Parcel. This North Parcel includes the Stadium Parcel and areas and environmental units that are immediately adjacent to the Stadium Parcel. The North Parcel is an approximately 127-acre portion, which is the Parcel as addressed in this report.

Overall, the Main Street facility has been divided into 26 study areas. Of these study areas, the 4 areas that encompass the Airport/Klondike Area include the North and South Airport Areas and the North and South Klondike Areas. For the North Parcel, portions of 2 of the study areas consisting of the North Airport Area and the North Klondike Area are included in the North Parcel. Within the portions of the 2 study areas present in the North Parcel, and addressed in this report, there are a total of 4 sub-areas. Within the 4 sub-areas, there are a total of 6 environmental units that are described in 5 USTMs.

The Rentschler Airport Area is generally limited to the runway and taxi areas. The aircraft hangars and the airport terminal are not included, as these areas are not part of the Airport/Klondike Area. The airfield was opened in 1931 as an all-turf airfield. Improvements were made through the years that resulted in the present configuration of two main runways. The Rentschler Airport was used for the take-off and landing of a variety of commercial and military aircraft. Fueling, deicing and miscellaneous aircraft repair operations were conducted in other areas of the Main Street facility. Based on available information it was determined that the fueling, repair and deicing operations were conducted at the South Klondike Tie-Down Area and the airport hangars located near the Main Street facility.

Army Barracks that were used as temporary quarters of military personnel were once located on the northwestern portion of the airfield. The Army Barracks extended from the northern end of the north-south runway continued westward off the Site. There were approximately thirty-three buildings (including barracks, mess hall, recreation, dispensary, supply and administration operations, warehouses, school, and radio) that were part of the Army Barracks complex. Fuel



storage and vehicle maintenance areas or buildings were not indicated on the available drawing. Sixteen septic systems of various sizes were installed to handle the sanitary wastewater from the various buildings. Based on the available information, eight of the septic systems were located on the northern end of Rentschler Airport with three appearing to be within the Stadium Parcel and eight of the septic systems were located off the Site.

The former Silver Lane Pickle Company Area had three different areas where there were USTs. All of the former USTs were located adjacent to buildings, based on the presence of fill pipes noted on a site plan (Peterson & Hoffman Engineers, 1964). From the northeast to the southwest, there were two USTs with a dispensing pump at one location, three USTs at a second location, and one UST at a third location. The former contents of the USTs are not known, but were likely to have been fuels. Additionally, along the western boundary of the former Silver Lane Pickle Company Area, there are several piles of soil which contain debris, including glass, tile, rubber, coal, charcoal, brick fragments, asphalt fragments, and concrete. The Silver Lane Pickle Company Area while being within the North Parcel is not within the Stadium Parcel.

The Outside Storage Area was located within the North Klondike Undeveloped Land Area. The unit is located to the northeast of the Undeveloped Land Area and measures approximately 180 feet by 360 feet. Based upon a review of aerial photographs, the unit is located in an area that may have been a pond between 1965 and 1969. After the area had been filled, this area was used until the mid-1970s for the storage of equipment and materials, including but not limited to, concrete pipe, large vehicles, and heavy equipment. The storage of the materials may have been associated with the various grading and filling projects for the airport.

The Soil Pile Area was located within the North Klondike Undeveloped Land Area. A soil pile, that appears to be the result of historic-filling operations, was located at the northern-most portion of the North Klondike Undeveloped Land Area. The soil pile, located toward the southwest of the Undeveloped Land Area, measures approximately 80 feet by 400 feet. A review of the 1965 aerial photograph indicates an area, located toward the western side of the Undeveloped Land Area, that is a light-colored area, probably sand, without vegetation.

The operations conducted at the North Parcel have resulted in several areas of concern that may have resulted in impacts to soil and/or groundwater at the North Parcel. These areas included the following:

- Rentschler Airport Runway Area
- Former Army Barracks Septic Systems
- Silver Lane Pickle Company Underground Storage Tanks



- Silver Lane Pickle Company Soil Piles
- North Klondike Undeveloped Land Outside Storage Area
- North Klondike Undeveloped Land Soil Pile.

9.2 Results of Soil Investigations

Investigation activities performed at the Airport/Klondike Area consisted of the collection and analysis of samples of soil and groundwater from sampling points located at the Airport/Klondike Area during the period from 1994 through approximately November 1997. The specific field activities conducted during each of the contaminant delineation investigations for the environmental units are presented in the USTMs.

With the exception of certain select samples, all soil samples collected during the period from 1994 through approximately November 1997 were submitted to the LEA Analytical Laboratory and analyzed for target VOCs. Based upon the results of the field headspace screening, visual or olfactory evidence, and descriptions included in the field sampling records, two soil samples from each soil boring were typically selected for analysis at an off-site analytical laboratory. Soil samples submitted to an off-site analytical laboratory were analyzed for the suite of analytes particular for each individual environmental unit. The specific suite of analytes for a given environmental unit included a combination of VOCs, SVOCs, target metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc), and TPH. Following the receipt of analysis for target metals at each environmental unit, extractable target metals analyses were requested on selected soils located above the approximate seasonal high water table. Extractable metals were analyzed for in these select soil samples utilizing the TCLP or the SPLP methods.

9.2.1.1 Rentschler Airport Runway Area

During airport expansion activities conducted at various times, fill was placed in low-lying areas of the North Airport. In order to investigate the potential for contaminated fill used in these low-lying areas, thirty-nine Geoprobe® soil borings, NA-SB-63 through NA-SB-101, were advanced to a depth of four feet in suspected low-lying portions of the North Airport. These low-lying areas were primarily identified from historical aerial photographs. Based on visual and instrument evidence, contaminated fill was not encountered during this investigation. Therefore, no samples were collected for subsequent laboratory analysis.



9.2.1.2 Former Army Barracks Septic Systems

During the GPR survey, several characteristics were noted that could have been indications of septic system components. However, these indications were located on UTRC property and not P&W's property. The GPR survey of P&W's property indicated only pipe-like structures. Three soil borings were advanced in the vicinity of locations that had GPR signatures indicating the possible presence of septic systems or previously disturbed areas. VOCs, SVOCs, and TPH were not detected in the soil samples. One or more of the metals analyzed were detected in each of the soil samples submitted for analysis. These metals include arsenic, barium, cadmium, chromium, copper, nickel, and zinc.

9.2.1.3 Silver Lane Pickle Company Area

In the North Airport Area, the former Silver Lane Pickle Company Area includes the areas of the former USTs associated with the pickle company operations, and the soil piles presumably associated with razing of the buildings. VOCs detected in soil samples collected from soil borings installed in this area included: acetone; BZ (screening); carbon disulfide; EBZ; EBZ (screening); methyl ethyl ketone; methylene chloride; PCE (screening); TL (screening); TCA (screening); TCE; TCE (screening); XYL; and, XYL (screening). SVOCs detected in soil samples collected from soil borings installed in this area included: benzo[b]fluoranthene; fluoranthene; naphthalene; and, pyrene. TPH were detected in soil samples collected in this area at a maximum concentration of 10,500 mg/kg.

For the Silver Lane Pickle Company Area, the data were compared against the criteria included in the RSRs and the site-wide background soil concentrations for metals. The concentrations of some of the metals detected in the soil samples were not typical of background concentrations. Higher than background concentrations of barium, chromium, lead, and zinc were detected in several soil samples from borings NA-SB-30, NA-SB-36, NA-SB-38, NA-SB-41, NA-SB-42, NA-SB-45, and NA-SB-49. In addition, the lead concentration detected in borings NA-SB-42, NA-SB-45 and NA-SB-49 exceeded the tabulated RDEC and IDEC. Arsenic was detected in borings NA-SB-45 and NA-SB-49 at concentrations that exceed the RDEC and IDEC. For TPH detected exceedances of the RDEC and the IDEC were noted in borings NA-SB-41, NA-SB-42, and NA-SB-49. In addition, the concentration of TPH in boring NA-SB-48 at a depth of 2 to 4 feet exceeds the RDEC.

9.2.1.4 North Klondike Undeveloped Land Outside Storage Area

In the North Klondike Area, the North Klondike Undeveloped Land Outside Storage Area is located to the northeast of the northern portion of the Klondike Undeveloped Land. The area



was used for the storage of materials and equipment, including vehicles. VOCs detected in soil samples collected from soil borings in this area included: acetone; EBZ (screening); methyl ethyl ketone; methylene chloride; PCE; PCE (screening); TL (screening); TCE; TCE (screening); and o-xylene (screening). The only SVOC detected in soil samples collected from soil borings in this area was 2-methylnaphthalene. The maximum concentrations of the 2-methylnaphthalene detected in the soil samples collected from the North Klondike Undeveloped Land Outside Storage Area was 2,900 µg/kg. TPH was detected in soil samples collected in this area at a maximum concentration of 13,000 mg/kg. The only PCB detected in soil samples collected from soil borings advanced in the vicinity of this unit was Aroclor 1260 at a maximum concentration of 61J µg/kg.

For the North Klondike Undeveloped Land Outside Storage Area, the concentrations of TPH detected were above the RDEC in the soil borings NK-SB-21, NK-SB-310 through NK-SB-314, NK-SB-322 through NK-SB-323, NK-SB-325 and NK-SB-326 at varying depth, ranging from 0 to 10 feet. Also, the concentrations of TPH detected in soil borings NK-SB-310 through NK-SB-311 were above the IDEC and the GBPMC. The concentration of TPH detected in test pit sample NK-TP-04N was above the RDEC.

9.2.1.5 North Klondike Undeveloped Land Soil Pile

During airport expansion activities conducted at various times, fill was placed in areas of the North Klondike. This filled area was primarily identified from historical aerial photographs. In order to investigate the potential for contaminated fill used in area, two hand auger soil borings, NK-SB-51 and NK-SB-52, were advanced to a depth of 8 feet within the limits of the soil pile. In addition, one test pit NK-TP-01 was advanced with a backhoe to a depth of 9 feet in the soil pile. Based on visual and instrument evidence, contaminated fill was not encountered during this investigation. No debris was encountered in the borings or the test pit. No visual or olfactory evidence of contamination was noted in the boring or test pit logs. Therefore, no samples were collected for subsequent laboratory analysis. VOCs were not detected in the soil samples. One or more of the metals analyzed were detected in each of the soil samples submitted for analysis. These metals include barium, chromium, copper, and zinc.

9.2.2 Results of Groundwater Investigations

Surface water protection and volatilization criteria apply to groundwater, regardless of the classification. Surface water protection criteria apply if the groundwater discharges to a surface water body, and volatilization criteria apply to groundwater within fifteen feet of the ground surface or a building. Consequently, groundwater data collected during the subsurface investigations conducted at the Site have been compared to tabulated numeric criteria presented



in the RSRs for surface water protection, and shallow groundwater quality was compared to tabulated volatilization criteria provided in the RSRs.

In the Silver Lane Pickle Company Area, several potential exceedances of the SWPC were noted for metals detected in groundwater. However, additional groundwater data from borings NA-SB-50 through NA-SB-54 indicate that the zinc concentrations from borings NA-SB-29 and NA-SB-38 do not exceed the RSRs and the SWPC is not applicable. The zinc emanating from borings NA-SB-29 and NA-SB-38 do not discharge directly to the brook at a concentration that exceeds the SWPC. Groundwater samples from NA-SB-50 through NA-SB-53, located between the brook and borings NA-SB-29 and NA-SB-38, have concentrations of zinc below the SWPC. These downgradient compliance points do not indicate an exceedance of the SWPC.

The RVC of the RSRs apply to groundwater within fifteen feet of the ground surface or a building. The RVC are designed to address the potential for VOCs volatilized from groundwater to migrate through the unsaturated zone to indoor air. No exceedances of the RVC were noted for the constituents detected in groundwater at the North Parcel.

9.3 Remedial Activities

Remedial activities were conducted to remove contaminated from areas within the North Parcel. Soil removals were conducted in the Silver Lane Pickle Company Area and the North Klondike Undeveloped Land Outside Storage Area. In general, soil remediation was conducted by removal of the soil to a depth below or beyond that anticipated to be contaminated. Upon removal of the impacted soil, confirmational sampling was conducted to confirm that all contaminated soil was excavated prior to backfilling the area. Due to exceedances of the RDEC and IDEC for TPH and RDEC and IDEC for metals and the GBPMC for TPH in selected soil samples, impacted soil was excavated and removed from the following areas: the Silver Lane Pickle Company Area and the North Klondike Undeveloped Land Outside Storage Area.

To avoid the need for an ELUR at the Site, and in accordance with Section 22a-133k-2(b) of the RSRs, the RDEC must be met. To satisfy the RDEC, soils within 15 feet of the ground surface must exhibit contaminant concentrations lower than the applicable criteria. Whenever feasible, the soil removal was performed to a point where the remaining levels were below RDEC. In cases where a significant volume of material was present that exceeded the RDEC or in cases of exceedances of the IDEC, the goal of the removal activity was to remove the exceedances within 4 feet of the ground surface. Soil with contaminant concentrations above the IDEC within four feet of the ground surface was excavated along with the future recording of an ELUR for soils below 4 feet for the area to satisfy the criteria for inaccessible soil.



The pollutant mobility criteria of the RSRs are designed to protect groundwater from contaminants that may leach from soils during infiltration events. To satisfy the pollutant mobility criteria in a GB groundwater classification area, concentrations of substances in soil above the seasonal high water table must not exceed the pollutant mobility criteria applicable to GB areas. Sampling locations with concentrations that exceeded the pollutant mobility criteria were excavated to the seasonal high water table.

9.4 Conclusions

A comprehensive environmental site investigation and remediation was conducted at the Airport/Klondike Area including the North Parcel. The investigation performed for the North Parcel is adequate to identify potential release areas and to characterize the nature and extent of contamination associated with those release areas. For these investigations of the North Parcel, this evaluation includes an evaluation of the locations and depths at which the release would have likely occurred, sampling locations and depths relative to potential release areas, and potential contaminant transport pathways.

No further investigation is warranted in the Rentschler Airport Runway Area due to the low likelihood of a release. Laboratory analyses from investigations performed and visual and instrument evidence indicate that jet fuel or aviation gasoline contamination is not present. Furthermore, the network of groundwater sampling locations located in the Rentschler Airport Runway Area provides groundwater analytical data on the lack of impacts to groundwater.

For the Army Barracks Septic Systems, the soil boring data were compared against the tabulated numeric criteria included in the RSRs and the site-wide background soil concentrations for various inorganic constituents. The concentrations of the metals detected in these samples are typical of site-wide background, and are not indicative of a release from this environmental unit. For the metals detected in soil, no exceedances of the RDEC or IDEC were noted. Based on the analytical results, there is no evidence that a release has occurred at this unit. It is believed that the area has been adequately characterized and no further action is warranted for the Former Army Barracks Septic Systems.

For the North Klondike Undeveloped Land Soil Pile, the soil sampling data were compared against the tabulated criteria included in the RSRs and the site-wide background soil concentrations for various inorganic constituents. The concentrations of the metals detected in these samples are typical of site-wide background, and are not indicative of a release from this environmental unit. For the metals detected in soil, no exceedances of the RDEC or IDEC were noted. Based on the analytical results, there is no evidence that a release has occurred at this



unit. It is believed that the area has been adequately characterized and no further action is warranted for the Undeveloped Land Soil Pile.

With the completion of the soil removal activities in the Silver Lane Pickle Company Area and the North Klondike Undeveloped Land Outside Storage Area, soils with contaminant concentrations above the IDEC within four feet of the ground surface have been excavated as of July 1, 2000. For the remaining soils, an ELUR for soils below four feet (eight feet for the Outside Storage Area) will be necessary for the area to satisfy the IDEC criteria for inaccessible soil. In accordance with Section 22a-133k-3(g)(2)(A), post-remediation groundwater monitoring must be performed to confirm the effectiveness of the soil remediation in eliminating a source of contaminants to groundwater in the release areas. Upon completion of the remediation, the length of the monitoring program is a minimum of two years for a GB area as stated in Section 22a-133k-3(g)(3)(A)(iii) of the RSRs.



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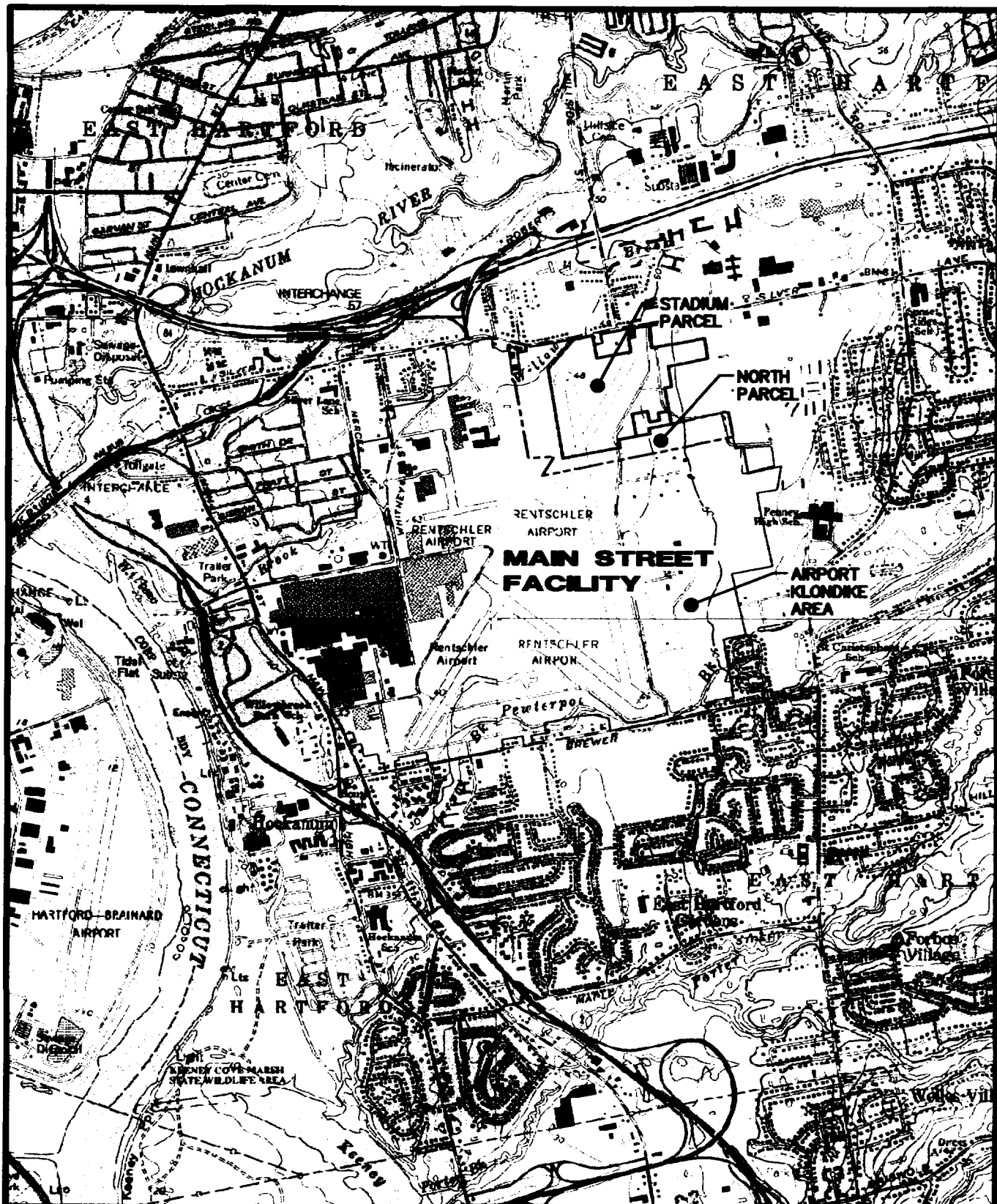
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TABLES

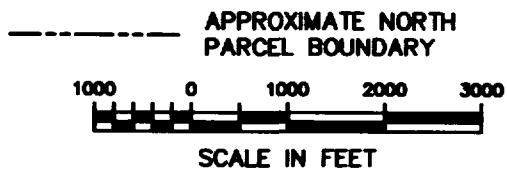
Table 1
Study Area and Sampling Type Identifiers
Airport/Klondike Area, Pratt & Whitney, East Hartford, Connecticut

Area Designation	Area	Sampling Type Identifier	Explanation
AB	A Building	MW	Monitoring Well
BB	B Building	PZ	Piezometer
CB	C Building	SW	Surface Water
DB	D Building	SD	Sediment
EB	E Building	CC	Concrete Chip
FB	F Building	SS	Surface Soil
GB	G Building	SB	Soil Boring
HB	H Building		
JB	J Building		
KB	K Building		
LB	L Building		
MB	M Building		
CS	Colt Street Facility		
EA	Engineering Area		
ET	Experimental Test Airport Laboratory		
LM	Area Outside Buildings L and M		
NA	North Airport Area		
NT	North Test Area		
NW	North Willgoos Area		
PH	Powerhouse Area		
SA	South Airport Area		
SK	South Klondike Area		
ST	South Test Area		
SW	South Willgoos Area		
WT	Waste Treatment Area		
XT	Experimental Test Area		

FIGURES



LEGEND

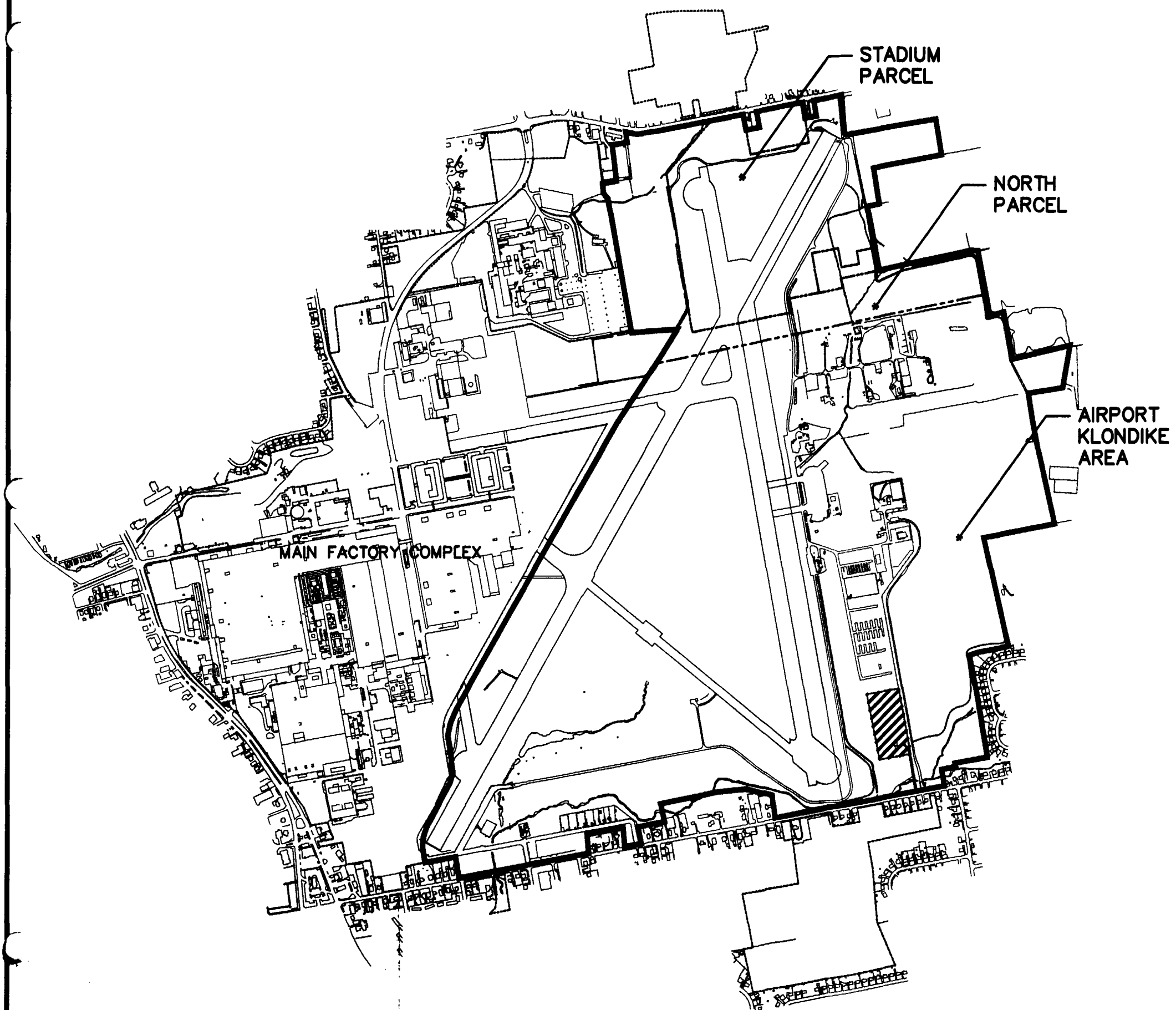


MAIN STREET FACILITY USGS TOPOGRAPHIC MAP

Comm.No.
88UT015

FIGURE 1



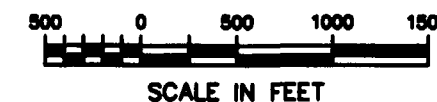


LEGEND

- Property line (Approximate location)
- Stadium Parcel Boundary (Approximate location)
- North Parcel Boundary (Approximate location)
- Airport Klondike Area (Approximate location)

MAP REFERENCE:

SURVEY CONTROL BY FUSS & O'NEILL, INC
 PHOTOGRAMMETRY BY GOLDEN AERIAL SURVEYS, INC
 DATE OF PHOTOGRAPHY: 3/17/91



NORTH PARCEL		
PRATT & WHITNEY MAIN STREET FACILITY SITE PLAN		
Comm.No. 88UT015	FIGURE 2	

DRAWINGS

**US EPA New England
RCRA Document Management System
Image Target Sheet**

RDMS Document ID # 2246

Facility Name: PRATT & WHITNEY - MAIN STREET

Facility ID#: CTD990672081

Phase Classification: R-5

Purpose of Target Sheet:

☒ **Oversized (in Site File)** ☐ **Oversized (in Map Drawer)**

☐ **Page(s) Missing (Please Specify Below)**

☐ **Privileged** ☐ **Other (Provide
Purpose Below)**

Description of Oversized Material, if applicable:

**DRAWING 1: NORTH PARCEL LAYOUT AND
TOPOGRAPHY**

☒ **Map** ☐ **Photograph** ☐ **Other (Specify Below)**

*** Please Contact the EPA New England RCRA Records Center to View This Document ***

**US EPA New England
RCRA Document Management System
Image Target Sheet**

RDMS Document ID # 2246

Facility Name: PRATT & WHITNEY - MAIN STREET

Facility ID#: CTD990672081

Phase Classification: R-5

Purpose of Target Sheet:

☒ **Oversized (in Site File)** ☐ **Oversized (in Map Drawer)**

☐ **Page(s) Missing (Please Specify Below)**

☐ **Privileged** ☐ **Other (Provide
Purpose Below)**

Description of Oversized Material, if applicable:

**DRAWING 2: NORTH PARCEL SOIL SAMPLING
LOCATIONS**

☒ **Map** ☐ **Photograph** ☐ **Other (Specify Below)**

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**US EPA New England
RCRA Document Management System
Image Target Sheet**

RDMS Document ID # 2246

Facility Name: PRATT & WHITNEY - MAIN STREET

Facility ID#: CTD990672081

Phase Classification: R-5

Purpose of Target Sheet:

☒ **Oversized (in Site File)** ☐ **Oversized (in Map Drawer)**

☐ **Page(s) Missing (Please Specify Below)**

☐ **Privileged** ☐ **Other (Provide
Purpose Below)**

Description of Oversized Material, if applicable:

DRAWING 3: NORTH PARCEL TEST PIT LOCATIONS

☒ **Map** ☐ **Photograph** ☐ **Other (Specify Below)**

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**US EPA New England
RCRA Document Management System
Image Target Sheet**

RDMS Document ID # 2246

Facility Name: PRATT & WHITNEY - MAIN STREET

Facility ID#: CTD990672081

Phase Classification: R-5

Purpose of Target Sheet:

☒ **Oversized** (in Site File) ☐ **Oversized** (in Map Drawer)

☐ **Page(s) Missing** (Please Specify Below)

☐ **Privileged** ☐ **Other** (Provide
Purpose Below)

Description of Oversized Material, if applicable:

**DRAWING 4: NORTH PARCEL GROUNDWATER
SAMPLING LOCATIONS**

☒ **Map** ☐ **Photograph** ☐ **Other** (Specify Below)

*** Please Contact the EPA New England RCRA Records Center to View This Document ***

APPENDIX A

Loureiro Engineering Associates, Inc. Standard Operating Procedures

**Standard Operating Procedure
for
Geoprobe® Probing and Sampling**

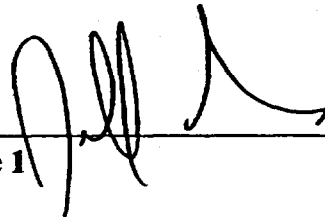
SOP ID: 10011

Date Initiated: 11/10/94

Revision #002: 11/20/96

Approved By:

Name 1



Date

11/20/96

Name 2

Gail J. Batchelder

Date

11/20/96

SOP ID: 10011
Date Initiated: 11/10/94
Revision #003: 06/17/97
Page 1 of 13

REVISION RECORD

<u>Rev #</u>	<u>Date</u>	<u>Additions/Deletions/Modifications</u>
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Standard Operating Procedure for Geoprobe® Probing and Sampling

1. Statement of Purpose

The objective of this procedure is to collect a discrete soil sample at depth using Geoprobe® probing and sampling methodologies and to recover the sample for visual inspection and/or chemical analysis. Procedures for soil sampling for chemical analysis are included in *Standard Operating Procedures for Soil Sampling*.

2. Background

2.1. Definitions

Geoprobe® *: A vehicle-mounted, hydraulically-powered, soil probing machine that utilizes static force and percussion to advance small diameter sampling tools into the subsurface for collecting soil core, soil gas, or groundwater samples.

* (Geoprobe is a registered trademark of Kejr Engineering, Inc., Salina, Kansas.)

Large Bore Sampler: A 24-inch long x 1-3/8-inch diameter piston-type soil sampler capable of recovering a discrete sample that measures up to 320 ml in volume, in the form of a 22-inch x 1-1/16-inch core contained inside a removable liner.

Liner: A 24-inch long x 1-1/8-inch diameter removable/replaceable, thin-walled tube inserted inside the Large Bore Sampler body for the purpose of containing and storing soil samples. Liner materials include brass, stainless steel, Teflon®, and clear plastic (either PETG or cellulose acetate butyrate).

2.2. Discussion

In this procedure, the assembled Large Bore Sampler is connected to the leading end of a Geoprobe® brand probe rod and driven into the subsurface using a Geoprobe® machine. Additional probe rods are connected in succession to advance the sampler to depth. The sampler remains sealed (closed) by a piston tip as it is being driven. The piston is held in place by a reverse-threaded stop-pin at the trailing end of the sampler. When the sampler tip has reached the top of the



desired sampling interval, a series of extension rods, sufficient to reach depth, are coupled together and lowered down the inside diameter of the probe rods. The extension rods are then rotated clock-wise (using a handle). The male threads on the leading end of the extension rods engage the female threads on the top end of the stop-pin, and the pin is removed. After the extension rods and stop-pin have been removed, the tool string is advanced an additional 24 inches. The piston is displaced inside the sampler body by the soil as the sample is cut. To recover the sample, the sampler is recovered from the hole and the liner containing the soil sample is removed.

3. Required Equipment

The following equipment is required to recover soil core samples using the Geoprobe® Large Bore Sampler and driving system. Sample liners for the Large Bore Sampler are available in four different materials. Liner materials should be selected based on sampling purpose, analytical parameters, and data quality objectives.

<u>Large Bore Sampler Parts</u>	<u>Part Number</u>
STD Piston Stop-pin, O-ring	AT-63, 63R
LB Cutting Shoe	AT-660
LB Drive Head	AT-661
LB Sample Tube	AT-662
LB Piston Tip	AT-663
LB Piston Rod	AT-664
LB Clear Plastic Liner	AT-665
LB Brass Liner	AT-666
LB Stainless Steel Liner	AT-667
LB Teflon® Liner	AT-668
LB Cutting Shoe Wrench	AT-669
Vinyl End Caps	AT-641
Teflon® Tape	AT-640T

<u>Geoprobe® Tools</u>	<u>Part Number</u>
Probe Rod (3 foot)	AT-10B
Probe Rod (2 foot)	AT-10B
Probe Rod (1 foot)	AT-10B
Drive Cap	AT-11B
Pull Cap	AT-12B



Extension Rod	AT-67
Extension Rod Coupler	AT-68
Extension Rod Handle	AT-69
<u>Optional</u>	<u>Part Number</u>
LB Manual Extruder	AT-659K
Extension Rod Jig	GS-469
LB Pre-Probe	AT-146B
<u>Additional Tools</u>	
Vise Grips	
Open Ended Wrench (3/8-inch)	
1-inch or Adjustable Wrench	

4. Procedures

4.1. Utilities Clearance

- 4.1.1. Notify the appropriate "one call" utility notification service (e.g. Call Before You Dig) at least three working days prior to commencing operations on a site. The locations of all proposed borings must be clearly marked in the field prior to notification.
- 4.1.2. Particularly upon larger private sites, consult with the owner or other person knowledgeable about the site as to locations of potential private or abandoned utilities and locate these prior to beginning work. Upon the discretion of the project manager, a pipe locator can also be used to assist in locating utilities.
- 4.1.3. Note that OSHA may have additional requirements for location of utilities.
- 4.1.4. All efforts to locate underground utilities should be properly documented in the field log book prior to onset of the work scheduled.

4.2. OSHA

The foreman or supervisor of the drilling crew shall be the Competent Person as required by OSHA for all of their work. However, this does not relieve the LEA representative from bringing to his or her attention conditions which may be unsafe or present a hazard to the drilling crew, the general public, or other workers on the site. The LEA representative is responsible for ensuring that LEA



activities are conducted in accordance with the site-specific Health and Safety Plan.

4.3. Site Preparation

- 4.3.1. A sufficient area shall be cordoned off to restrict access to the work area. This area shall be termed an "Exclusion Zone".
- 4.3.2. An equipment decontamination area shall be assembled as described in Section 4.11 within the exclusion zone.
- 4.3.3. The area immediately surrounding the proposed borehole and the back portion of the rig (including the tires) shall be covered with 5 mil plastic sheeting. A hole of sufficient diameter shall be cut from the center of the plastic sheeting to facilitate auger advancement.
- 4.3.4. All personal protective equipment shall be donned.

4.4. Assembly

- 4.4.1. Install a new AT-63R O-ring into the O-ring groove on the AT-63 Stop-pin.
- 4.4.2. Seat the pre-flared end of the LB Liner (AT-665, -666, -667, or -668) over the interior end of the AT-660 Cutting Shoe. It should fit snugly.
- 4.4.3. Insert the liner into either end of the AT-662 Sample Tube and screw the cutting shoe and liner into place. If excessive resistance is encountered during this task, it may be necessary to use the AT-669 LB Shoe Wrench. Place the wrench on the ground and position the sampler assembly with the shoe end down so that the recessed notch on the cutting shoe aligns with the pin in the socket of the wrench. Push down on the sample tube while turning it, until the cutting shoe is threaded tightly into place.
- 4.4.4. Screw the AT-664 Piston Rod into the AT-663 Piston Tip. Insert the piston tip and rod into the sample tube from the end opposite the cutting shoe. Push and rotate the rod until the tip is seated completely into the cutting shoe.
- 4.4.5. Screw the AT-661 Drive Head onto the top end of the sample tube, aligning the piston rod through the center bore.



- 4.4.6. Screw the reverse-threaded AT-63 Stop-pin in the top of the drive head and turn it **counter-clockwise** with a 3/8-inch wrench until tight. Hold the drive head in place with a 1-inch or adjustable wrench while completing this task to assure that the drive head stays completely seated. The assembly is now complete.

4.5. Pilot Hole

A pilot hole is appropriate when the surface to be penetrated contains gravel, asphalt, hard sands, or rubble. Pre-probing can prevent unnecessary wear on the sampling tools. A Large Bore Pre-Probe (AT-146B) may be used for this purpose. The pilot hole should be made only to a depth above the sampling interval. Where surface pavements are present, a hole may be drilled with the Geoprobe® using a Drill Steel (AT-32, -33, -34, or -35, depending upon the thickness of the pavement), tipped with a 1.5-inch diameter Carbide Drill Bit (AT-36) prior to probing. For pavements in excess of 6 inches, the use of compressed air to remove cuttings is recommended.

4.6. Driving

- 4.6.1. Attach an AT-106B 1-foot Probe Rod to the assembled sampler and an AT-11B Drive Cap to the probe rod. Position the assembly for driving into the subsurface.
- 4.6.2. Drive the assembly into the subsurface until the drive head of the LB sample tube is just above the ground surface.
- 4.6.3. Remove the drive cap and the 1-foot probe rod. Secure the drive head with a 1-inch or adjustable wrench and re-tighten the stop-pin with a 3/8-inch wrench.
- 4.6.4. Attach an AT-105B 2-foot Probe Rod and a drive cap, and continue to drive the sampler into the ground. Attach AT-10B 3-foot Probe Rods in succession until the leading end of the sampler reaches the top of the desired sampling interval.

4.7. Preparing to Sample

- 4.7.1. When sampling depth has been reached, position the Geoprobe® machine away from the top of the probe rod to allow room to work.
- 4.7.2. Insert an AT-67 Extension Rod down the inside diameter of the probe rods. Hold onto it and place an AT-68 Extension Rod Coupler on the



top threads of the extension rod (the down-hole end of the leading extension rod should remain uncovered). Attach another extension rod to the coupler and lower the jointed rods down-hole.

- 4.7.3. Couple additional extension rods together in the same fashion as in Step 2. Use the same number of extension rods as there are probe rods in the ground. The leading extension rod must reach the stop-pin at the top of the sampler assembly. When coupling extension rods together, you may opt to use the GW-469 Extension Rod Jig to hold the down-hole extension rods while adding additional rods.
- 4.7.4. When the leading extension rod has reached the stop-pin down-hole, attach the AT-69 Extension Rod Handle to the top extension rod.
- 4.7.5. Turn the handle **clockwise** (right-handed) until the stop-pin detaches from the threads on the drive head. Pull up lightly on the extension rods during this procedure to check thread engagement.
- 4.7.6. Remove the extension rods and uncouple the sections as each joint is pulled from the hole. The Extension Rod Jig may be used to hold the rod couplers in place as the top extension rods are removed.
- 4.7.7. The stop-pin should be attached to the bottom of the last extension rod upon removal. Inspect it for damage. Once the stop-pin has been removed, the sampler is ready to be re-driven to collect a sample.

4.8. Sample Collection

- 4.8.1. Reposition the Geoprobe® machine over the probe rods, adding an additional probe rod to the tool string if necessary. Make a mark on the probe rod 24 inches above the ground surface (this is the distance the tool string will be advanced).
- 4.8.2. Attach a drive cap to the probe rod and drive the tool string and sampler another 24 inches. Use of the Geoprobe®'s hammer function during sample collection may increase the sample recovery in certain formations. Do not over-drive the sampler.

4.9. Retrieval

- 4.9.1. Remove the drive cap on the top probe rod and attach an AT-12B Pull Cap. Lower the probe shell and close the hammer latch over the pull ap.



- 4.9.2. With the Geoprobe® foot firmly on the ground, pull the tool string out of the hole. Stop when the top (drive head) of the sampler is about 12 inches above the ground surface.
- 4.9.3. Because the piston tip and rod have been displaced inside the sample tube, the piston rod now extends into the 2-foot probe rod section. In loose soils, the 2-foot probe rod and sampler may be recovered as one piece by using the foot control to lift the sampler the remaining distance out of the hole.
- 4.9.4. If excessive resistance is encountered while attempting to lift the sampler and probe rod out of the hole using the foot control, unscrew the drive head from the sampler and remove it with the probe rod, the piston rod, and the piston tip. Replace the drive head onto the sampler and attach a pull cap to it. Lower the probe shell and close the hammer latch over the pull cap and pull the sampler the remaining distance out of the hole with the probe machine foot firmly on the ground.

4.10. Sample Recovery

- 4.10.1. Detach the 2-foot probe rod if it has not been done previously.
- 4.10.2. Unscrew the cutting shoe using the AT-669 LB Cutting Shoe Wrench, if necessary. Pull the cutting shoe out with the liner attached. If the liner doesn't slide out readily with the cutting shoe, take off the drive head and push down on the side wall of the liner. The liner and sample should slide out easily.

4.11. Core Liner Capping

- 4.11.1. The ends of the liners can be capped off using the AT-641 Vinyl End Cap for further storage or transportation. A black end cap should be used at the bottom (down end) of the sample core and a red end cap at the top (up end) of the core.
- 4.11.2. On brass, stainless steel, and Teflon® liners, cover the end of the sample tube with AT-640T Teflon® Tape before placing the end caps on the liner. The tape should be smoothed out and pressed over the end of the soil core so as to minimize headspace. However, care should be taken not to stretch and, therefore, thin the Teflon® tape.



4.12. Sample Removal

- 4.12.1. Large Bore Clear Plastic and Teflon® Liners can be slit open easily with a utility knife for the samples to be analyzed or placed in appropriate containers.
- 4.12.2. Large Bore Brass and Stainless Steel liners separate into four 6-inch sections. The AT-659K Large Bore Manual Extruder may be used to push the soil cores out of the liner sections for analysis or for transfer to other containers.
- 4.12.3. The procedures for collection of soil samples for chemical analysis are described in the *Standard Operating Procedure for Soil Sampling*.
- 4.12.4. Soil samples collected for archive purposes shall be placed into 4-ounce clear soil jars and labeled with boring numbers, depth, and commission number.

4.13. Equipment Decontamination and Cleaning

- 4.13.1. Prior to conducting a boring, the LEA representative will ensure that all necessary equipment is clean and decontaminated, including the rig, all augers and probing equipment, samplers, brushes, and any other tools or equipment. Decontamination procedures may vary slightly from those presented below, dependent upon the particular types of contaminants encountered.
- 4.13.2. A section of 5-mil (minimum) plastic sheeting shall be cut of sufficient size to underlie the decontamination area to contain any discharge of decontamination solutions.
- 4.13.3. The following solutions (as appropriate for the anticipated contaminants) shall be prepared and placed in 500-ml laboratory squirt bottles: methanol solution (less than 10%); 10% nitric acid solution; 100% hexane solution; and distilled deionized (DI) water. A fifth solution of phosphate-free detergent and tap water (approximately 2.5 gallons) shall be prepared in a five-gallon bucket. Only those solutions required for site-specific conditions will be used at a given site, as specified in the site-specific work plan.
- 4.13.4. All loose debris shall be removed from the augers and spatulas into an empty 5-gallon bucket or plastic sheeting using a stiff bristled brush.



4.13.5. The order of decontamination solutions is as follows:

- 1) Detergent Scrub
- 2) DI Water Rinse
- 3) Hexane Rinse (to be used only if separate-phase petroleum product, other than gasoline, is present)
- 4) DI Water Rinse
- 5) 10% Nitric Acid Rinse (to be used only when metals are suspected as potential contaminants)
- 6) DI Water Rinse
- 7) Methanol Rinse (<10% solution)
- 8) Air Dry

4.13.6. Each piece of decontaminated sampling equipment will be wrapped in aluminum foil to maintain cleanliness.

4.13.7. An alternative to the procedure described above requires that the larger equipment be cleaned using a high-pressure wash and steam cleaning in an area constructed to contain spent decontamination fluid and debris (plastic sheeting bermed with timber is usually sufficient). Alternative methods of cleaning may be more appropriate for an individual piece of equipment for site conditions based upon a knowledge of site contaminants, and may be used at the discretion of the LEA representative. Section 5.4 provides additional information on management of potentially contaminated fluids and materials.

4.13.8. At the end of the project day, all used equipment shall be decontaminated. All spent decontamination solutions will be handled and disposed of in accordance with all applicable municipal, state and federal regulations.

4.14. VOC Monitoring

4.14.1. A portable volatile organic compound (VOC) analyzer shall be available on site and shall be used to screen all cuttings and fluids (if any) removed from the hole.

4.14.2. Since, in general, it cannot be presumed that there is no contamination at a given site, all cuttings and/or fluids which show a reading on the VOC analyzer that is above background shall be containerized or drummed, as appropriate, on site. Additional information on management of potentially contaminated fluids and materials is presented in Section 5.4.



5. Sample Collection and Documentation

5.1. Sample collection following removal from borehole.

- 5.1.1. The sample tube shall be opened by the LEA representative and immediately scanned using the VOC analyzer using the approach described in Section 5.2.
- 5.1.2. The LEA representative will record on the boring log at a minimum: description of the material in the sampler, depth, VOC analyzer reading, material size gradation using the Burmeister system, color, moisture, and relative density.
- 5.1.3. Prior to reuse, the sampler shall be decontaminated using the procedures described in Section 4.13.
- 5.1.4. Soil samples collected for archival purposes shall be placed into 4-ounce clear soil jars and labeled with the boring number, depth, and commission number.
- 5.1.5. The procedures for collection of soil samples for chemical analysis are described in the *Standard Operating Procedure for Soil Sampling*.

5.2. Field Analysis

- 5.2.1. The following procedure shall be used to obtain readings of the VOCs present in a soil sample:
 - 1) Obtain an aliquot of soil (approximately 50 grams) from the split spoon and placed into a Ziploc™ plastic bag or equivalent and sealed.
 - 2) Agitate the sample, assuring that all soil aggregates are broken, for two minutes.
 - 3) Carefully break the seal of the bag enough to insert the VOC probe.
 - 4) Record the maximum reading obtained on the appropriate forms, as described in Section 5.3.

5.3. Field Documentation

- 5.3.1. The following general information shall be recorded in the field log book and /or appropriate field forms:
 - Project and site identification



- LEA commission number
- Field personnel
- Name of recorder
- Identification of borings
- Collection method
- Date and time of collection
- Types of sample containers used, sample identification numbers and QA/QC sample identification
- Field analysis method(s)
- Field observations on sampling event
- Name of collector
- Climatic conditions, including air temperature
- Chronological events of the day
- Status of total production
- Record of non-productive time
- QA/QC data
- Name of drilling firm
- Location of boring(s) on site insufficient detail to relocate boring at a future time (include sketch)

5.3.2. The following information shall be recorded on the boring log:

- Project name, location, and LEA commission number
- Borehole number, borehole diameter, boring location, drilling method, contractor, groundwater observations, logger's name and date
- Depth below grade, sample I.D. number, duplicate numbers, VOC analyzer reading, rig behavior (i.e. drilling effort, etc.)
- A complete sample description, including as a minimum: depth, material size gradation using the Burmeister system, color, moisture, and density. Should a well be constructed in a borehole, a complete well schematic shall be drawn and accurately labeled
- Use of water, including source(s) and quantity

5.3.3. The following information shall be recorded on the Field Quality Review Checklist:

- Reviewer's name, date, and LEA commission number
- Review of all necessary site activities and field forms
- Statement of corrective actions for deficiencies



5.3.4. The Field Instrument & Quality Assurance Record shall include the following information:

- Client's name, location, LEA commission number, date
- Instrument make, model, and type
- Calibration readings
- Calibration/filtration lot numbers
- Field personnel and signature

5.4. Disposal of Potentially Contaminated Materials

Potentially contaminated cuttings or fluids, as indicated by knowledge of the site, discoloration, VOC analyzer readings, or other evidence, shall be containerized on-site pending sampling and determination of hazardous waste status.

5.5. Refusal

Refusal is defined as failure to penetrate the subsurface materials to any greater depth using the maximum reasonable pressure limits of the Geoprobe® machine.

5.6. Bedrock

The term "bedrock" will not be used in a boring log or other description of subsurface materials that have been collected using the Geoprobe® machine, since a confirmational core cannot be collected.

5.7. Boring Abandonment

- 5.7.1. If the boring is not to be used for other purposes (i.e. monitoring well, soil vapor probe, soil vapor extraction well, etc.) it shall be abandoned.
- 5.7.2. The boring shall be filled and sealed with neat cement grout or high density bentonite clay grout as soon as the tools are withdrawn from the borehole.
- 5.7.3. Excess cuttings shall be containerized and sampled before disposal.
- 5.7.4. In paved areas, the upper three feet of the borehole shall be filled, up to two inches below the existing grade, with sand to allow for repairing of the pavement.
- 5.7.5. Pavement shall be repaired using cold patch asphalt filler or concrete.



6. Other

Depending on the specific site, other considerations may be applicable. Consult the OSHA regulations, applicable RCRA or CERCLA regulations, and the site-specific work plan for details.

7. References

Geoprobe® Systems, August 1993, "1993-04 Equipment and Tools Catalog".



**Standard Operating Procedure
for
Modified EPA Method 3810
Static Headspace
Analysis of Volatile Organic Compounds
Using the Photovac® 10S50 Gas Chromatograph**

SOP ID: 10002

Date Initiated: 01/15/91

Revision #013: 03/29/00

Approved By: Christina M. Clerney 3/29/00
Name 1 Date
N. Haland 3/29/00
Name 2 Date

REVISION RECORD

Rev #	Date	Additions/Deletions/Modifications
001	1/15/91	Initial Issue
002	1/29/93	Revisions throughout
003	5/19/94	Revisions throughout
004	7/25/94	Revisions throughout
005	8/9/94	Revisions throughout
006	10/1/94	Quality control section (Add)
007	6/7/95	Standard preparation (Del) Calibration check (Add)
008	4/16/96	Methanol extraction (Add) Project initiation form (Add) Frequency of detection limit studies (Add) Database entry procedure (Add) Documentation (Add)
009	5/19/97	Sample collection, preservation and storage (Add) Surrogate standard (Add) Database entry procedure(Edit)
010	10/11/99	Analysis of vinyl chloride
011	10/18/99	Revisions throughout
012	02/09/00	Retention time drift criteria Raw data review Tedlar® bag inspection Vinyl chloride surrogate Methanol preserved sample handling Attachment: Calibration Curve Concentrations
013	03/29/00	Revise section 11.4.1, acceptance criteria for surrogate recovery for soil, groundwater and vapor samples Change criteria for blank contamination in section 16.1 Add units to Attachment 1 tables



**Standard Operating Procedure
for
Modified EPA Method 3810
Static Headspace
Analysis of Volatile Organic Compounds
Using the Photovac® 10S50 Gas Chromatograph**

1. Statement of Purpose

This document describes procedures to be followed for the analysis of select volatile organic compounds by modified EPA method 3810-Static Headspace using the Photovac® 10S50 Gas Chromatograph. This method is applicable to groundwater, soil and air samples. The data may be used for screening purposes during environmental field investigations.

2. Scope and Application

2.1. Method Summary

Volatile organic compounds are separated using a Photovac® 10S50 gas chromatograph equipped with a CPSil 5 capillary column and a 10.6 eV photoionization detector. The temperature program is isothermal and the pressure remains constant. Computer acquisition is achieved through manual entry into the LEA MIS - Laboratory Information System.

2.2. Sample Types

This SOP applies to soil, soil vapor and groundwater samples.

2.3. Injection Technique

Samples are analyzed using direct injection of headspace.

3. Equipment

3.1. Equipment required for operations of the portable gas chromatograph shall include:

3.1.1. Distilled organic-free water

3.1.2. Standard



- 3.1.3. EPA vials (20 mL, 40 mL)
- 3.1.4. Gas tight syringes
- 3.1.5. Liquid syringes
- 3.1.6. Gas chromatograph (Photovac® 10S50)
- 3.1.7. Compressed air cylinder (ultra pure, zero grade air)
- 3.1.8. Air flow meter
- 3.1.9. 30 mL measuring block
- 3.1.10. Glass volumetric flasks (10 mL, 100 mL)
- 3.1.11. Clean gloves
- 3.1.12. Methanol, pesticide grade
- 3.1.13. Parafilm
- 3.1.14. Drying oven
- 3.1.15. Thermometer
- 3.1.16. GC Septa
- 3.1.17. Waste container
- 3.1.18. Tedlar® bags
- 3.1.19. Tedlar® bag septa
- 3.1.20. Safety glasses
- 3.1.21. Volumetric pipettes
- 3.1.22. Rubber bulb pipette filler
- 3.1.23. Hydrochloric acid
- 3.1.24. Alconox® laboratory detergent
- 3.1.25. Computer



- 3.1.26. Maxi-mix III mechanical agitator
- 3.1.27. Cpsil 5 analytical column
- 3.1.28. Cpsil 19 analytical column - vinyl chloride
- 3.1.29. 3.1.29. 10.6 and / or 11.7 eV photoionization lamp

4. Decontamination of Laboratory Glassware and Laboratory Syringes

4.1. Decontamination of Laboratory Glassware

- 4.1.1. Fill sink with tap water. Add Alconox® laboratory detergent.
- 4.1.2. Wash glassware thoroughly in soap/water.
- 4.1.3. Soak glassware overnight in soap/water in sink.
- 4.1.4. In the morning, rinse glassware thoroughly with tap water.
- 4.1.5. Rinse glassware three times with a 10 percent HCl solution.
- 4.1.6. Rinse glassware three times with distilled water.
- 4.1.7. Rinse glassware three times with methanol.
- 4.1.8. Place glassware in 80°C oven for one hour.

4.2. Decontamination of Laboratory Syringes

- 4.2.1. It is essential to maintain the syringes clean. Syringe blanks will be performed prior to, and in between, the analytical testing to confirm the cleanliness of the syringe. Use the three 20 mL vials containing pesticide grade methanol (MeOH) to decontaminate the syringes. The vials are labeled MeOH rinse #1, MeOH rinse #2, and MeOH rinse #3.
- 4.2.2. Remove the metal plunger from the syringe and gently wipe it with a cleaning tissue. Do not touch the plunger with your hands.
- 4.2.3. With the plunger back in the syringe, pump methanol from the vial labeled MeOH rinse #1 through the needle and barrel of the syringe. Remove plunger and wipe the plunger with a cleaning tissue.
- 4.2.4. Repeat step 3.2.3 using the methanol vial labeled MeOH rinse #2 and again with the methanol vial labeled MeOH rinse #3.
- 4.2.5. Air dry the syringe.
- 4.2.6. The syringe can be rapidly dried using heat as long as temperatures are kept below 50°C. The coefficient of expansion of the steel plunger is greater than glass, and the resultant pressure may split the glass barrel along the axis. Always keep drying temperatures below 50°C and never leave the plunger inside the barrel of the syringe while heating.

5. Sample Collection, Preservation, and Storage



- 5.1. All samples must be introduced into respective sample containers gently to reduce agitation, which might drive off volatiles.
 - 5.1.1. Vapor samples should be collected into Tedlar® bags using appropriate soil gas sampling equipment. Tedlar® bags are inspected prior to use. If any bag appears to be losing volume or shows excessive use, the bag is discarded.
 - 5.1.2. Groundwater samples should be poured into clean, dry 40 mL EPA VOA vials, with Teflon® lined septum caps. Should bubbling occur as a result of violent pouring, the vial must be emptied and refilled.
 - 5.1.3. There are two procedures for soil sample preparation. The type of sample preparation (water or methanol) must be defined in the data quality objectives of each project and communicated to the laboratory before the onset of the project.
 - 5.1.3.1. Water preparation method: soil samples are collected and weighed in the field using a portable field balance. Approximately 5 grams of soil is transferred into a clean, dry 40 mL EPA VOA vial. Distilled organic free reagent water is added to the soil to a total volume of 30 mL.
 - 5.1.3.2. The second soil preparation procedure entails using a 1:1 ratio of soil (grams) to methanol (mL). The amount of methanol and soil is recorded and used in the calculation of the final results. Details of the methanol extraction procedure are described in section 6.4.
 - 5.1.4. Groundwater and soil samples are preserved with HCl to a pH of less than two.
- 5.2. All samples should be labeled immediately after the sample container is filled. All samples should be logged onto an internal LEA chain-of-custody form.
- 5.3. Samples should never be collected near a running motor or exhaust. Discharged fumes may contaminate the samples.
- 5.4. VOA samples may become contaminated by diffusion of volatile organics through the septum during shipment and storage. To monitor possible contamination, a trip blank prepared from distilled deionized water should be carried throughout the sample storage and shipment process.



- 5.5. Samples must be stored at 4°C. The temperature of the refrigerator is monitored and recorded daily.

6. Sample Handling

6.1. Vapor Samples

- 6.1.1. Vapor samples should be analyzed within 24 hours from the time of collection, and generally take precedence over soil and water samples.
- 6.1.2. Vapor samples do not require an extraction procedure. Simply pierce the septum on the Tedlar® bag with the syringe. Withdraw an appropriate amount of sample into the syringe. Inject the sample into the GC.
- 6.1.3. All Tedlar® bags will be visually inspected prior to use for signs of leaks, cracks, discoloration and / or excessive use. If a Tedlar® bag appears to be losing volume, the bag will be discarded.
- 6.1.4. All Tedlar® bags will be visually inspected upon receipt into the laboratory. If a Tedlar® bag appears to be losing volume the bag will be discarded and the sample will be recollected. If recollection is not possible or practical, a note will be added to the final laboratory report indicating that the sample collection did not conform with standard operating procedures.
- 6.1.5. Loss of volume in the bag is tested by filling the bag with air and applying pressure on the bag. A solution of soap and water may also be applied to a suspected leak. Bubbling will occur at the site of the leak. Leaking bags will be discarded.

6.2. Water Samples

- 6.2.1. If water samples are not going to be analyzed immediately, store the 40 mL EPA vials containing the water samples with the cap side down to minimize any loss of VOCs through the cap. Refrigerate the samples.
- 6.2.2. All samples, whether they come into the lab directly from the field or are temporarily stored in the refrigerator should be allowed to reach room temperature before proceeding. Samples from the field should sit a minimum of 10 minutes. Samples from the refrigerator should sit a minimum of 30 minutes.



- 6.2.3. Temporary storage should be allowed only for soil or water samples and only if an excessive number of samples is received after 4:00 p.m. Temporary storage of environmental samples should not exceed 24 hours from the time of collection unless they are properly preserved.
- 6.2.4. Place water samples on the Maxi-mix III mechanical agitator or equivalent manual method. Shake for 2 minutes. Place samples in constant temperature water bath (~90°F) for a minimum of 2 minutes before injecting into the GC.

6.3. Soil Samples

- 6.3.1. Soil samples received in the laboratory, which have been prepared in the field, are handled the same as water samples. See Steps 6.2.1 through 6.2.4.
- 6.3.2. If samples are not prepared in the field then 5 grams of soil should be weighed in the laboratory and transferred to a 40 mL EPA vial. Reagent water is added to the vial to bring the total volume to 30 mL. The preservation requirements are the same as for water samples.
- 6.3.3. Special care should be taken to avoid clogging the syringe with particles of soil. A particulate clogging the syringe may eventually end up in the gas chromatograph altering the flow characteristics of the instrument.

7. Procedure for Extracting Soil Samples with Methanol

- 7.1. If it is determined, based on site specific data quality objectives, poor surrogate recovery, or site specific conditions (high organic content) that water does not effectively extract volatile organic compounds from the soil, then the following methanol extraction procedure should be used.
- 7.2. Tare a clean, dry empty sampling vial. Record the tare weight.
- 7.3. Add an appropriate amount of methanol to achieve a 1:1 ratio between the volume of methanol and mass of soil to be added. Record the volume of methanol added. Record the weight of the vial with the methanol.
- 7.4. Add the pre-measured soil plug from the disposable sampling device into the sampling vial containing methanol. Record the total weight of the vial, methanol and soil. Determine the mass of the soil and record.



- 7.5. Cap the vial and mix for two minutes using the mechanical agitator or appropriate mixing apparatus.
- 7.6. Transfer 1 mL of the extract to an appropriately labeled 40 mL VOA vial.
- 7.7. Add 29 mL of distilled organic free water to bring the total volume in the VOA vial to 30 mL.

8. Turning on the Instrument

The Photovac® 10S50 gas chromatograph can operate on an internal air supply source, or through a direct external carrier gas supply. The internal air cylinder should never be pressurized above 1500 psi. Accordingly, if an external carrier gas source is used, the outlet regulator pressure should never exceed 45 psi. Always maintain the gas cylinder securely chained, and shut off the cylinder valve and depressurize the line before disconnecting the regulator. Do not pressurize glass, and always wear safety glasses. Refer to the operator's manual for details about the Photovac® 10S50 GC.

- 8.1. Verify that the GC is operational and that the appropriate column and photoionization lamp is being used. Select the proper column and/or lamp based on the type of compounds to be analyzed.
- 8.2. Change the septum, which is located underneath injection port 1. Hand tighten the injection port. Do not overtighten!!! When handling the septum do not touch the septum with your hands. The Teflon® -coated side is placed facing down.
- 8.3. Adjust the flow using the red flow valve to about 5-10 mL/min. Use consistent flow rates so that the retention times are similar to past results. Be careful when adjusting the flow, the response time of the valve is around 8-10 minutes.
- 8.4. The auxiliary flow and the detector flow should be equal at this time. If not, you must adjust the flow using the needle valve that controls the auxiliary flow. Once again, be careful when adjusting the flow the response time of the valve is around 15 minutes.
- 8.5. Make sure the carrier gas (ultra pure zero grade air) is being delivered at 40 psi never higher!!! Pressure fluctuations will affect the system's operation.
- 8.6. Turn on the instrument. If the instrument does not display a ready message within 2 minutes, turn the instrument off and back on again. Wait for the LED display to show "ready".
- 8.7. If the instrument still does not return a "ready" signal, try tuning the photoionization lamp. Refer to the Owner's Manual for tuning instructions.



- 8.8. Once the instrument LED displays **"READY"**, set the date and time.
- 8.8.1. Press the **"USE"** button once. "Sample Library 1" will be displayed.
 - 8.8.2. Press the **"ENTER"** button. Type in the appropriate information for the date, year and time of day. Press **"ENTER"** when done.
 - 8.8.3. Press the **"TEST"** button to run a system check.
- 8.9. Set the instrument operating conditions based on the response of the compounds to be analyzed. Refer to the Owner's manual for explanation of instrument settings.
- 8.10. The gain of the instrument is initially at 2 (by default). Press the **"START" BUTTON AND THEN THE "ENTER"** button to run a GC Blank.
- 8.11. If the baseline is straight with no unknown peaks, hit the "gain" button and toggle with the "1" one step. Continue until the instrument is running at the chosen gain. Typically, the gain is set to 200 or 500 when using an 11.7 eV lamp and 10 or 20 when using a 10.6 eV lamp. The gain should be selected in such a way so that, depending on the levels of contamination encountered; the peaks should cover from 1/3 to 2/3 of the width of the paper. Less accurate results may be obtained outside this range. Press **"START"** and run a GC blank at the gain you intend to use.
- 8.12. If the baseline is not straight and/or unknown peaks are present, rerun a GC Blank at that same gain and continue running GC blanks until there is a straight baseline with no unknown peaks. If the peaks are persistent lower the gain and repeat the procedure.

9. Preparation of a Calibration Curve

- 9.1. Calibration standards are prepared from a secondary dilution of stock standards. Calibration is developed using a three to five point standard calibration curve. The standard concentrations selected should correspond to the range of concentrations of the unknown samples or cover the linear range of the instrument. One of the concentration levels should be at or near, but above, the method detection limit. Additional analyses may need to be performed to fully define the calibration curve. A minimum of three injections must be made at a single gain setting.
- 9.2. It is advisable to make additional injections using different syringe volumes and different gain settings. This will expand the range of the calibration.



- 9.3. Injection volumes and gain settings are dependent upon the instrument settings, the type of lamp used, the condition of the lamp, the type and condition of the column used, and the expected range of concentrations of the unknown samples to be analyzed. Operator's judgment should be used if no information is available on the concentrations or compounds anticipated. The Photovac 10S50 is not equipped for dual column or dual detector analysis; it may be necessary to use separate gas chromatographs if the target compounds require different columns or different detectors. For example, a CPSil 5 capillary would be used on one GC to detect BTEX, 1,1,1-TCA, TCE and PCE and a CPSil 19 capillary column would be used on another GC for the detection of vinyl chloride.

9.3.1. Soil and Aqueous Standard Preparation

- 9.3.1.1. Remove the custom standard mixtures from the refrigerator. Allow 30 minutes for the standards to reach ambient temperature.
- 9.3.1.2. Dilute each custom solution as necessary to prepare an appropriate range of concentrations. A five-point calibration covering the concentration range of 5 µg/l to 100 µg/l is generally an effective working range. The range can be modified based upon project-specific requirements.
- 9.3.1.3. Each custom standard is prepared by withdrawing an appropriate volume of the standard and transferring that volume into a clean dry 100 mL flask of distilled water. Inject the standard below the surface area of the water and not into the headspace.
- 9.3.1.4. Invert the 100 mL flask gently three times. Do not shake!!!
- 9.3.1.5. Pour off the neck of the flask into the waste container (approximately 20 mL).
- 9.3.1.6. Add 30 mL of the standard to a clean unused 40 mL EPA vial leaving 10 mL of headspace. Close the cap on the vial.
- 9.3.1.7. Label the vial with the standard number.
- 9.3.1.8. Place the vial in a constant temperature water bath (~90°F) with the cap side of the vial facing down.
- 9.3.1.9. Repeat steps 9.3.1.2 through 9.3.1.8 for each standard.



- 9.3.1.10. Immediately prior to injecting each standard into the gas chromatograph, remove one 40 mL vial from the water bath.
- 9.3.1.11. Shake the vial vigorously using the mechanical agitator or equivalent manual method for precisely two minutes.
- 9.3.1.12. Return the vial to the water bath and allow two minutes for equilibration.
- 9.3.1.13. Inject an appropriate amount of *headspace* from the vial into the gas chromatograph. Never inject water or other liquid into the GC!
- 9.3.1.14. Remove a second vial from the water bath and repeat steps 9.3.1.10 through 9.3.1.13. Continue this process until you have enough injections to represent a well-defined calibration curve.
- 9.3.1.15. Enter the calibration data into "Calibration Information" in the laboratory database program. See Section 17.0 for instructions about entering data.
- 9.3.1.16. Once initial calibration of the gas chromatograph is performed, the calibration is acceptable as long as the results for the continuing calibration check sample meets the analytical requirements for precision (± 20 percent). When this criterion is no longer acceptable, the GC must be recalibrated.

9.3.2. Vapor Standard Preparation

For all compounds with the exception of vinyl chloride:

- 9.3.2.1. Add an appropriate volume of pure neat standard to a clean 1 L Tedlar bag.
- 9.3.2.2. Transfer appropriate volumes of the primary gas standard as prepared in 9.3.2.1 into sequential 1 L Tedlar bags to obtain the appropriate dilution necessary for calibration.
- 9.3.2.3. Inject an appropriate volume of gas standard from each of the secondary dilution Tedlar bag directly into the GC.



For vinyl chloride:

- 9.3.2.4. Withdraw an appropriate volume of vinyl chloride standard from the gas cylinder.
- 9.3.2.5. Inject an appropriate volume of the gas standard directly into the gas chromatograph. Vary the dilution volumes to prepare a calibration curve within an appropriate working range.

10. Preparation of the Continuing Calibration Check Standard

For soil and aqueous samples:

- 10.1. Decontaminate the appropriate laboratory glassware and syringe(s) before preparing standard. See section 4.0 for Decontamination of Laboratory Glassware and Syringes.
- 10.2. Preparation of the primary standard (to be prepared once a month).

It is important to perform the following procedure in a consistent manner to enhance method reproducibility.

- 10.2.1. Remove the appropriate neat compound vial from the freezer. Allow 30 minutes for vial to reach room temperature.
- 10.2.2. Wearing safety glasses and operating under the fume hood use a 10 mL volumetric pipette to withdraw 10 mL of high purity grade methanol and transfer to a clean, dry 10 mL volumetric flask.
- 10.2.3. Place a glass stopper on the flask.
- 10.2.4. Using a decontaminated syringe, withdraw an appropriate volume of neat compound from the vial. The volume of neat compound to be used is based on the desired final concentration of your standard.
- 10.2.5. Remove the glass stopper from the 10 mL volumetric flask and inject the appropriate volume of neat compound into the 10 mL volumetric flask. Be sure to inject below the surface of the methanol, not into the air above the methanol. Recap the neat compound vial. Replace the glass stopper on the 10 mL volumetric flask.
- 10.2.6. Carefully invert the flask 3 times. Do not shake.



- 10.2.7. Wrap parafilm around the stopper and neck of the flask.
- 10.2.8. Label, date and initial the flask.
- 10.2.9. Place flask in refrigerator.
- 10.2.10. Tightly wrap parafilm around cap and neck of the neat compound vial and return to freezer to minimize volatilization.
- 10.3. Preparation of the continuing calibration intermediate standard (to be prepared once daily)
 - 10.3.1. Remove the primary standard from the refrigerator and allow it to come to room temperature (approximately 30 minutes). Remove the parafilm from the standard.
 - 10.3.2. Wearing safety glasses and operating under the fume hood fill one 100 mL volumetric flask with 100 mL of distilled water so that the bottom of the meniscus coincides with the mark on the neck of the flask.
 - 10.3.3. Inject an appropriate volume of the primary standard into the 100 mL flask of distilled water. Inject below the surface of the water and not into the air. Put the stopper on the primary standard flask. Replace the stoppers on the intermediate standard flasks.
 - 10.3.4. Invert the 100 mL flask gently three times. Do not shake!!!
 - 10.3.5. Pour off the neck of the flask into the waste container (approximately 20 mL).
 - 10.3.6. Fill a clean unused 40 mL EPA vial all the way to the top. Cap the vial. Make sure there is no air bubble in the vial.
 - 10.3.7. Pierce the septum of the 40 mL vial with two disposable syringes. While allowing air to enter into the vial through one open-ended syringe, remove 10 mL of the standard with the other syringe.
 - 10.3.8. Label and date the vial. Place the standard in a constant temperature water bath (~90°F) with the cap side of the vial facing down. Immediately prior to injecting into the gas chromatograph, shake each vial vigorously using the mechanical agitator or equivalent manual method for precisely two minutes. Return the vial to the constant temperature water bath and allow to equilibrate for two minutes.



- 10.3.9. Reseal the primary standard (10 mL volumetric flask) and return it to the refrigerator.
- 10.3.10. At the end of the day, pour the remaining liquids into a waste container. Only dilute organic solutions should be poured into the container. Refer to LEA's Waste Management Plan.
- 10.3.11. Return all equipment to its original storage place. Decontaminate all glassware. Report any deficiencies or equipment and supply needs to the laboratory manager.
- 10.3.12. The intermediate standard can only be used on the day of preparation and should be discarded at the end of each day. Refer to the Waste Management Plan for proper disposal practices. Always store the 40 mL EPA vial with the cap side down when not in use.

For vapor samples:

For all compounds with the exception of vinyl chloride:

- 10.3.13. Add an appropriate volume of pure neat standard to a clean 1 L Tedlar bag.
- 10.3.14. Transfer an appropriate volume of the gas standard as prepared in 5.3.13 into a second 1 L Tedlar to obtain the appropriate dilution necessary for calibration.
- 10.3.15. Add an appropriate volume of surrogate to the secondary dilution Tedlar
- 10.3.16. Inject an appropriate volume into the gas chromatograph.

For vinyl chloride:

- 10.3.17. Withdraw an appropriate volume of vinyl chloride standard from the gas cylinder.
- 10.3.18. Inject an appropriate volume of the gas standard directly into the gas chromatograph.

11. Surrogate Standard

- 11.1. Surrogate standards are used to monitor both the performance of the analytical system and the effectiveness of the method in dealing with each sample matrix.



Every sample, reagent water blank, and standard is spiked with an appropriate volume of surrogate standard.

- 11.2. Soil and Groundwater samples: surrogates for soil samples are added to the 40 mL EPA vial prior to injection into the gas chromatograph.

11.2.1. Chlorobenzene is used as the surrogate for soil samples. The primary standard is prepared by spiking 5 μ L of neat chlorobenzene standard into 10 mL of methanol. Each 30 mL sample is spiked with 5 μ L of the primary standard. The final concentration of surrogate in the extract is 93 μ g/L.

- 11.3. Vapor samples: surrogates for vapor samples are added to the Tedlar® bag prior to analysis.

11.3.1. Chlorobenzene is used as the surrogate for vapor samples. A primary standard is prepared by injecting 50 μ L of neat chlorobenzene into a 1 L Tedlar bag containing ultra-pure zero grade air. Each standard, QC sample and field sample is spiked with 100 μ L of the primary standard. The final concentration of surrogate in the vapor sample is 5.5 mg/m³.

11.3.2. Vinyl chloride vapor sample: acetone is used as the surrogate for vinyl chloride samples. The primary standard is prepared by injecting 25 μ L of neat acetone into a 1 L Tedlar bag containing ultra-pure zero grade air. Each QC sample and field sample is spiked with 100 μ L of the primary standard. The final concentration of acetone in the vapor samples is 1.98 mg/m³.

- 11.4. Acceptance criteria and corrective action

11.4.1. The acceptance criteria for surrogate recovery for soil, groundwater and vapor samples is 70-130 percent.

11.4.2. If a surrogate is recovered outside the acceptance window, the sample must be reanalyzed to determine if the original recovery was a result of poor laboratory performance or matrix interference.

11.4.2.1. The analyst may use professional judgement to reanalyze only select soil samples within a sample delivery group when soil samples that are known to contain high organic content are being analyzed. It is not necessary to analyze



every sample twice when the matrix is known to exhibit interferences.

12. Method Detection Limits

- 12.1. A method detection limit (MDL) study shall be performed for all target compounds according to procedures specified in 40 CFR 136, Appendix B.
- 12.2. An MDL study shall be performed at a minimum of once annually.
- 12.3. Additional MDL studies must be performed whenever instrument operating conditions are changed in such a way that would affect or change the limits of detection of any or all target compounds.

13. Project Initiation

- 13.1. Modifications to this standard operating procedure may be necessary in order to meet project and/or site specific requirements.
 - 13.1.1. All modifications to this standard operating procedure shall be approved by the laboratory manager and / or laboratory director.
- 13.2. Project Initiation Form
 - 13.2.1. Prior to the onset of every new project, a project initiation form should be submitted to the laboratory by the project manager or appropriate personnel assigned to the project.
 - 13.2.2. Depending upon the nature of the project, a brief meeting to review project-specific requirements should be arranged between the project manager and laboratory personnel prior to the onset of the sampling/analyses program.
 - 13.2.3. On-going meetings, particularly throughout large-scale projects, are encouraged to keep an open line of communication between laboratory personnel, project managers, and field samplers.

14. Sample Analysis

- 14.1. The gas chromatograph shall be equipped with the proper photoionization detector; analytical column and system operating conditions needed to effectively perform analyses in accordance with applicable project specific requirements.



- 14.2. After samples have been placed in the water bath (~90°F), shaken for two minutes then equilibrated for at least two minutes, the samples are ready for analysis. All vials should be stored upside-down, to minimize vapor losses through the septum and/or cap.
- 14.3. The injection procedure is a critical step towards successful GC operation. Good technique will lend good reproducibility, accuracy, and precision.
- 14.4. Pierce the septum of the 40 mL EPA vial containing your sample with a Hamilton Gas-tight syringe. Withdraw an appropriate volume of headspace from the sample vial. **DO NOT INJECT ANY LIQUID!!!** The volume of headspace and the syringe size necessary to extract the appropriate amount of headspace may vary depending upon the degree of sample contamination, instrument operating conditions and type/condition of lamp installed. Operator judgment may be inherent. If the unknown sample is expected to be highly concentrated, inject a small volume at a lower gain setting. Injecting too much may cause damage to the GC or its components.
- 14.5. Syringes are most accurate when volumes between 10-90 percent of the total syringe volume are used. Loss of accuracy may result outside of this range.
- 14.6. Rest the syringe containing your sample in the injection port. Do not pierce the septum of the injection port. Press the "Start" button then the "Enter" button. You will hear the pump go on. At the end of the pump cycle, push the syringe through the septum and all the way into the injection port. Push the plunger into the syringe barrel. Quickly withdraw the syringe from the injection port.

15. Procedure for Extracting Soil Samples with Methanol

- 15.1. If it is determined, based on poor surrogate recovery, or site specific conditions (high organic content), that water does not effectively extract volatile organic compounds from the soil, then the following methanol extraction procedure should be used.
- 15.2. Tare a clean, dry empty sampling vial. Record the tare weight.
- 15.3. Add an appropriate amount of methanol to achieve a 1:1 ratio between the volume of methanol and mass of soil to be added. Record the volume of methanol added. Record the weight of the vial with the methanol.
- 15.4. Add the pre-measured soil plug from the disposable sampling device into the sampling vial containing methanol or weigh an appropriate mass of soil. Record



the total weight of the vial, methanol and soil. Determine the mass of the soil and record.

- 15.5. Cap the vial and mix well for two minutes.
- 15.6. Transfer 1 mL of the extract to an appropriately labeled 40 mL VOA vial.
- 15.7. Add 29 mL of distilled organic free water to bring the total volume in the VOA vial to 30 mL.
- 15.8. Analyze the sample according to the procedure described in Section 14.0 Sample Analysis.

16. Quality Control Procedure

- 16.1. An instrument blank, syringe blank and a laboratory replicate are to be run at a minimum, every 20 samples, or once per day if less than 20 samples are analyzed. If all samples are clean (non-detected), it is not necessary to run instrument blanks and syringe blanks as often. The clean samples confirm that the instrument is contaminant free. Operator judgment must be exercised. Acceptable criteria for method blank contamination is that no target analytes at concentrations greater than the quantitation limit and no non-target compounds that interfere with the identification or quantitation of target analytes. If a blank sample does not meet the acceptance criteria, the source of the blank contamination must be identified and eliminated, if possible, and the blank must be reanalyzed.
- 16.2. Additional syringe blanks, instrument blanks and duplicates are to be run depending on the nature of the samples being analyzed. Operator judgment is essential. Sufficient blank analyses and duplicate analyses should be performed to confirm the validity of the analyses. Highly contaminated samples may require more blanks to confirm that the instrument is contaminant free.
- 16.3. A reagent water blank is to be run each time a new lot of reagent water is used.
- 16.4. A calibration check sample will be run with each batch of samples (approximately 20 samples per batch). The retention time of all compounds must be within ± 30 seconds of the retention time of the respective compound in the continuing calibration check sample. If the retention time of any given compound drifts outside the acceptable window (± 30 seconds), another calibration check sample will be analyzed and the retention times will be updated for that batch.



17. LEA Laboratory Database Computer Procedure

- 17.1. All samples, calibration standards, and QA/QC analyses are to be entered into the LEA laboratory database. Refer to the "LEA User's Guide for Computer Procedures" for additional guidance.
- 17.2. Logging into the laboratory database.
 - 17.2.1. Log onto computer with your name and password.
 - 17.2.2. Double click on the LEA MIS icon.
 - 17.2.3. Click on Field or Analytical Data.
 - 17.2.4. Click on Analysis Information.
- 17.3. Checking Samples into the database.
 - 17.3.1. A chain of custody must accompany all samples submitted to the laboratory. The chain must be signed and dated by the field sampler.
 - 17.3.2. The laboratory personnel must sign and date the chain of custody to acknowledge receipt of the samples. If there is any discrepancy, the laboratory personnel must notify appropriate personnel and resolve the discrepancy immediately.

18. Entering analyses into the database

- 18.1. Click on Analysis Information.
 - 18.1.1. Click on the Sample Information Tab at the bottom of the screen, enter the laboratory number assigned to a specific chromatogram (for example, 96-1329-512) and all appropriate sample information fields.
 - 18.1.2. Click on the Analysis Information Tab at the bottom of the screen and enter all appropriate information relating to the analysis (i.e., retention times, areas, sample mass, methanol volume, etc.).
- 18.2. Printing Analysis Reports
 - 18.2.1. Click on Daily Results Summary.
 - 18.2.2. In the Sample Summary Form window, enter the commission number and the analysis date you wish to print.



18.2.3. Click the OK button.

18.3. Printing Client Reports

18.3.1. Click on Make Client Release Forms.

18.3.2. In the Client Release Form window, enter the commission number and the date you wish to print. Enter the Project Managers name in the box "released to" then click the OK button. If you wish to print a single client report, click the By Number button to set the selection to lab number. Enter the lab number you wish to print (for example, 96-1329-512) then click the OK button.

19. Analytical Report Documentation

19.1. Each chromatogram is taped to the appropriate analysis report.

19.1.1. Vapor Samples: a primary check and review of each raw data analysis report will be performed within 24 hours by the analyst. A secondary review will be performed by a peer analyst.

19.1.2. Preliminary data may be submitted to project managers immediately after the primary review. The sample summary data is stamped "preliminary."

19.1.3. Soil Samples: a primary check and review of each raw data analysis report will be performed within 24 hours by the analyst. A secondary review will be performed by a peer analyst. Final client reports and data are submitted to project managers after the secondary/final review.

19.2. After final review, the original analysis reports along with a copy of the final client reports will be filed in an appropriately labeled project notebook in the laboratory.

20. Laboratory Documentation

20.1. Instrument maintenance is recorded for each GC in a dedicated logbook. Each logbook will be available for inspection and review.

20.2. A calibration check of the analytical balance will be performed each day that the balance is in use. The calibration is recorded in a logbook and is available for inspection and review.



- 20.3. Temperature logbooks are maintained and recorded for the sample refrigerator and the standard refrigerator. The temperature of the refrigerator should be maintained at approximately 4°C. The logbooks are available for inspection and review.

END OF DOCUMENT



ATTACHMENT 1**SOIL CALIBRATION CURVE CONCENTRATIONS**

(µg/L)

Compound	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
1,1,1-Trichloroethane	133	199.5	332.5	399	665	
Benzene	5	10	25	35	50	70
Trichloroethylene	7	25	35	50	70	
Toluene	5	10	25	50	70	
Tetrachloroethylene	5	10	25	35	50	70
Chlorobenzene	5	10	25	50	70	
Ethylbenzene	5	10	25	50	70	
m,p - Xylene	5	10	25	50	75	
o - Xylene	5	10	25	35	50	

VAPOR CALIBRATION CURVE CONCENTRATIONS(mg/m³)

Compound	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Vinyl Chloride	0.01	0.02	0.03	0.05	0.06	0.09
1,1,1-Trichloroethane	9.975	11.97	13.3	15.2	16.6	
Benzene	0.22	0.286	0.33	0.396	0.44	
Trichloroethylene	2.8	3.3	3.7	4.3	4.6	
Toluene	6.53	7.83	8.70	10.0	10.9	
Tetrachloroethylene	1.21	1.45	1.62	1.86	2.02	
Chlorobenzene	4.12	4.96	5.50	6.33	6.87	

*The concentrations provided may vary depending upon operating conditions. This table is provided as general guidance.



**Standard Operating Procedure
for
Soil Sampling**

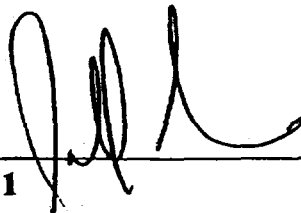
SOP ID: 10006

Date Initiated: 2/20/90

Revision #003: 11/21/96

Approved By:

Name 1



Date

11/21/96

Name 2

Gail T. Batchelder

Date

11/21/96

REVISION RECORD

<u>Rev #</u>	<u>Date</u>	<u>Additions/Deletions/Modifications</u>
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Standard Operating Procedure for Soil Sampling

1. Statement of Purpose

This document discusses procedures for collection of soil samples for analytical analysis. Methods for collection and quality assurance/quality control requirements are covered under separate SOPs. The procedures outlined in this document are in accordance with ASTM Standard D 420 and the EPA document Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846). These procedures may vary slightly according to the needs of specific projects.

2. Equipment and Equipment Documentation

2.1. Equipment required for the collection of soil samples shall include:

- Stainless steel spatula
- Distilled water
- Hand towels
- Polyethylene plastic sheeting
- Sample collection jars
- Clean disposable gloves
- Field documentation
- Indelible marker
- Cooler, cold packs and maximum/minimum thermometer
- Custody seals and sample labels
- Polythethylene plastic sheeting (5-mil thickness)

2.2. Cleaning and Decontamination

- 2.2.1. Prior to collecting a soil sample, the LEA representative will ensure that all necessary sampling equipment is clean and decontaminated according to the site-specific work plan or collection method SOPs.
- 2.2.2. Upon completion of all sampling requirements and prior to leaving the site, all equipment used for sampling shall be cleaned and decontaminated. All generated decontamination fluids shall be



disposed of in accordance with the site-specific work plan and all municipal, state, and federal requirements.

3. Sampling Protocols

3.1. Preliminary Sampling Procedures

3.1.1. Sample Bottles

3.1.1.1. A Laboratory Request Form shall be completed and submitted to the laboratory with following information:

- **Project name**
- **LEA commission number**
- **Date of submittal and date needed**
- **Quantity of sample locations and sample points at each location**
- **Type(s) of samples**
- **Analytes, detection limits and QA/QC needed**
- **Cooler(s) required**
- **Number of Chain-of-Custody forms requested**

3.1.1.2. Check bottles against Laboratory Request Form for completeness. The bottles should also be checked for damage and cleanliness. Confirm with laboratory personnel the adequacy of the preservatives used.

3.1.1.3. Obtain preprinted labels and paperwork through the information management system.

3.1.1.4. Label all bottles prior to sampling with the information and check for accuracy. This step may also be performed in the field prior to sample collection.

3.1.1.5. The total number of sample sets shall be increased by 10% to allow for possible breakage during transport to sites or other contingencies (minimum: one additional sample bottle set per event).

3.1.1.6. A cooler with adequate ice or cold packs should be obtained from the laboratory to insure that the collected samples remain at 4°C during transport. Packing material



should also be obtained to insure against breakage during transport.

3.1.2. Site Preparation

3.1.2.1. A level table shall be placed within the exclusion zone and covered with polyethylene sheeting.

1.1.1.2. Decontaminated spatulas shall be placed on the table. Prelabeled sample bottles shall be placed in a convenient location and in order of sample collection.

3.2. Sampling Procedures

3.2.1. All personal protective equipment (PPE) should be donned and maintained in accordance with the site-specific work plan or health and safety plan during all sampling procedures. In the event that no PPE has been specified for a particular sampling event, disposable latex gloves should be donned, as a minimum, during all sampling procedures.

3.2.2. The particular soil sampling device (i.e. hand auger, split spoon, etc.) shall be retrieved from the point of collection and placed on a level table covered in polyethylene sheeting.

3.2.3. Using a decontaminated stainless steel spatula, the soil shall be transferred directly into prelabeled soil sampling containers. Care should be taken to completely fill the sample container intended for VOC analysis. Large void spaces within the container shall be minimized by packing, not agitation.

3.2.4. Wipe the rim of the sample container with a clean paper towel to remove excess solids which would prevent adequate sealing of the sample container and seal the container.

The order of sample collection shall be as follows:

- samples to be analyzed for volatile organic compounds at the LEA Analytical Laboratory
- samples to be analyzed for volatile organic compounds using appropriate EPA methodologies
- samples to be screened for total volatile organic compounds with a total volatile organic analyzer



- samples to be analyzed for other organic and inorganic constituents

3.2.5. As required, affix a custody seal, noting the date and time of collection across the cap/bottle interface and on the sample label. Place and secure sample within cooler and complete all sample collection documentation.

3.3. Post-Sampling Procedures

3.3.1. As required, upon completion of all sampling procedures for a particular site, secure the lid of the cooler using packaging tape with the Chain-Of-Custody inside.

3.3.2. Should the laboratory be local, transport the samples directly to the laboratory and present them to the sample manager. The representative of LEA should witness the verification of the Chain-Of-Custody and obtain a carbon copy for filing in the project notebook.

3.3.3. Should the laboratory be distant, arrange for transport with a reputable carrier service. The cooler and samples shall be secured for transport, and all mailing documentation secured onto the top of the cooler. Unless otherwise specified, delivery shall be overnight. A request for confirmation of acceptance should be made to the carrier at the time of pick-up.

3.4. Documentation

3.4.1. The following general information shall be recorded in the field log book and/or on the appropriate field forms:

- Project and site identification
- LEA commission number
- Field personnel
- Name of recorder
- Identification of borings
- Collection method
- Date and time of collection.
- Types of sample containers used, sample identification numbers and QA/QC sample identification
- Preservative(s) used
- Parameters requested for analysis
- Field analysis method(s)
- Field observations on sampling event



- Name of collector
- Climatic conditions, including air temperature
- Internal temperature of field and shipping (refrigerated) containers
- Chronological events of the day
- Status of total production
- Record of non-productive time
- QA/QC data

3.4.2. The following information shall be recorded on the Field Quality Review Checklist:

- Reviewer's name, date, and LEA commission number
- Review of all necessary site activities and field forms
- Statement of corrective actions for deficiencies

3.4.3. The following information shall be recorded on the chain-of-custody record:

- Client's name and location
- Boring or sampling location identification
- Date and time of collection
- Sample number
- Container type, number, size
- Preservative used
- Signature of collector
- Signatures of persons involved in the chain of possession
- Analyses to be performed
- Type and number of samples

3.4.4. The following information shall be provided on the sample label using an indelible pen:

- Sample identification number
- Date and time of collection
- Place of collection
- Parameter(s) requested (if space permits)

3.4.5. The following information shall be recorded on the sample collection data sheet:

- Client name, location and LEA commission number
- Boring or sampling location identification number



- Date and time of collection
- Sample number
- Depth sample was obtained
- Field instrumentation reading



**Standard Operating Procedure
for
Sample Management
Associated with the LEA Analytical Laboratory**

**SOP ID: 10012
Date Initiated: 01/17/95
Revision: #002: 06/19/97**

Approved By: N. Halanth 6/19/97
Name 1 Date
Christina M. Clemmey 6/19/97
Name 2 Date

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure for Sample Management Associated with the LEA Analytical Laboratory

1. Statement of Purpose

This document discusses procedures for collection, handling and transport of soil, water and vapor samples for analysis by the Loureiro Engineering Associates (LEA) Analytical Laboratory. The procedures outlined in this document are a condensed version of several other SOPs. This SOP is intended to serve as a quick reference for the field sampler. Quality Assurance Quality Control (QA/QC) criteria for collection of blank samples is included in this SOP.

2. General Sampling Guidelines for all Sample Types (i.e. soil, water, vapor)

- Define sampling objectives with Project Manager.
- Obtain sampling equipment.
- Ensure that all necessary sampling equipment is properly decontaminated.
- Obtain necessary sample containers (40 ml vials, Tedlar® bags) and labels. Include enough containers for specified QA/QC samples.
- Obtain a cooler with adequate ice or cold packs to ensure that the collected samples remain at about 4° C during transport. Packing material should also be obtained to provide protection against breakage.
- Obtain necessary personal protective equipment (PPE) as specified in the site specific work plan or Health and Safety Plan. In the event that no PPE has been specified for a particular sampling event, disposable gloves should be used as a minimum, during all sampling collection activities.
- Obtain all the necessary paper work including the site specific work plan, Health and Safety Plan, applicable SOPs, field forms, chain-of-custody and sample documentation forms.

3. Soil Samples

- 3.1. Refer to SOP #10006, *Soil Sampling*, for details related to sample collection.
- 3.2. Calibrate the portable field balance according to the manufacturer's specifications, which are included in Attachment A to this SOP.
- 3.3. Place a clean, dry 40 ml vial on the balance and tare (zero) the balance and vial.

- 3.4. Using a decontaminated stainless steel spatula transfer approximately 5 grams of soil into the 40 ml vial. Due to rapid volatilization time is more critical than the exact mass of the soil (4.0 g - 6.0 g is acceptable).
 - 3.5. Record the mass of the soil.
 - 3.6. Immediately transfer the 40 ml vial from the balance to the 30 ml measuring block. Add distilled water so that the bottom of the meniscus coincides with the top of the block.
 - 3.7. Cap the vial immediately.
 - 3.8. Store the vial cap side down in a cooler (maintained at about 4° C) containing ice or cold packs.
 - 3.9. Complete the internal chain-of-custody along with all appropriate sample documentation forms.
- 4. Water Samples**
- 4.1. Refer to SOP #10004, *Liquid Sample Collection and Field Analysis* for details related to sample collection.
 - 4.2. In order to ensure that the groundwater sample is representative of the formation, it is important to minimize physical alteration or chemical contamination of the sample during the withdrawal process.
 - 4.3. Place a properly labeled 40 ml vial in a 30 ml measuring block.
 - 4.4. Using the appropriate decontaminated sampling equipment, withdraw the water sample from its origin and transfer 30 ml of sample into the pre-labeled 40 ml vial. The bottom of the meniscus is to be lined up with the top of the measuring block. Due to the potential for volatilization, avoid excessive agitation, air bubbles, etc. during the sample transfer process.
 - 4.5. Immediately cap the 40 ml vial.
 - 4.6. Store the vial cap side down in a cooler (maintained at about 4° C) containing ice or cold packs.

5. Vapor Samples

- 5.1. Refer to SOP #10014, *Soil Vapor Surveying*, for details related to sample collection.
- 5.2. Attach the soil vapor sampler and clean Tygon® tubing to the appropriate vapor sampling port.
- 5.3. Purge the system for 2 minutes.
- 5.4. Attach a clean Tedlar® bag to the discharge end of the soil vapor sampler and purge the Tedlar® bag by filling and emptying it three times.
- 5.5. Fill the Tedlar® bag a fourth time, close the valve on the bag, remove the bag from the system.
- 5.6. Label the Tedlar® bag with the appropriate sampling information.
- 5.7. Complete all necessary sample documentation forms.
- 5.8. Store the samples in a cool, dry place. Avoid leaving the samples in the sun or other sources of heat.

6. QA/QC Procedures for Soil, Water and Vapor Samples

- 6.1. Refer to SOP #10005, *Quality Assurance/Quality Control Measures for Field Activities*, for details related to sample collection.
- 6.2. All QA/QC samples are collected following the same procedure described for the appropriate matrix.
- 6.3. All QA/QC samples shall be properly documented.
- 6.4. At the conclusion of each sampling day, a quality control review shall be conducted using the Field Quality Review Checklist and the Daily Field Report.
- 6.5. The following QA/QC samples are to be collected.
 - 6.5.1. Trip Blank
 - 6.5.1.1. Contaminated trip blanks may indicate contamination of the samples during the field trip or shipment to the lab, cross-contamination between the samples, contaminated sample vials, or improper handling.

6.5.1.2. Trip blanks shall be used only with samples that are to be analyzed for volatile organic compounds..

6.5.1.3. One trip blank shall be included per sample, soil, sediment, and/or groundwater samples that are to be analyzed for volatile organic compounds per sampling day.

6.5.1.4. Trip blanks are prepared using analyte-free deionized water prior to the sampling event, usually by the laboratory providing the sampling containers.. Each trip blank is placed in a 40 ml glass VOA vial for which it serves as a trip blank field activities associated with and is carried in the same shipping container as the sample(s). Trip blanks should not be opened until received.

6.5.2. Equipment/Rinsate Blank

6.5.2.1. The purpose of an equipment/rinsate blank is to determine if decontamination procedures were adequate or if any of the equipment might contribute contaminants to the sample.

6.5.2.2. An equipment/rinsate blank is prepared by running analyte-free deionized water through all sample collection equipment (bailers, pumps, filters, split spoon) and placing it in the appropriate sample containers for analysis. If equipment has been decontaminated in the field, the equipment/rinsate blank should be collected after decontamination procedures have been performed.

6.5.2.3. Equipment/rinsate blanks shall be used when sampling surface water, groundwater, soil, and sediment.

6.5.2.4. One equipment/rinsate blank shall be collected for each sample bottle/preservation technique/analysis procedure per matrix per sampling event.

7. Sample Transport

7.1. All soil and water samples collected in 40 ml VOA vials to be submitted to the LEA Analytical Laboratory for analysis:

7.1.1. Must be stored with the cap of the vial facing downward.

7.1.2. Must be transported in a cooler with ice.

7.1.3. Must be accompanied by a Chain-of-Custody.

7.2. Vapor samples collected in Tedlar® bags to be submitted to the LEA Analytical Laboratory for analysis:

7.2.1. Must be submitted to laboratory personnel immediately upon arrival.

7.2.2. Must be kept away from sources of heat (i.e. sun, etc.).

7.2.3. Must be accompanied by a Chain-of-Custody.

8. If the Samples are Brought in During Regular Working Hours

8.1. Submit the samples along with the "ORIGINAL" LEA Internal Chain-of-Custody to the laboratory. Sign, date and record the time of relinquishing the samples. Laboratory personnel will check the samples against the Chain-of-Custody then sign, date, and record the time of receiving the samples.

8.2. The "ORIGINAL" Chain-of-Custody will be returned to the sampler. The laboratory will maintain a "COPY" of the Chain-of-Custody.

8.3. Submit a "COPY" of the Chain-of-Custody to the LEA Data Manager.

9. If the Samples are Brought in After Hours

9.1. The samples should be placed in the refrigerator in the lab (40 ml EPA VOA vials should be stored with the CAP SIDE DOWN to prevent any loss of VOCs through the cap).

9.2. Sign, date and record the time of relinquishing the samples.

9.3. Leave the "ORIGINAL" LEA Internal Chain-of-Custody under the magnet on the refrigerator door.

9.4. Submit a "COPY" of the Chain-of-Custody to the LEA Data Manager.

9.5. After the samples are signed in by the laboratory, the original Chain-of-Custody will be returned to the field sampling personnel. The lab will maintain a copy of the Chain-of-Custody.

9.6. Follow up the next day to confirm that the sample was properly received, and the analysis properly completed.

**Standard Operating Procedure
for
Soil Vapor Surveying**

SOP ID: 10014
Date Initiated: 9/1/92
Revision #003: 9/01/97

Approved By: _____

Name 1

9/1/97
Date

Name 2

9/1/97
Date

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure for Soil Vapor Surveying

1. Statement of Purpose

1.1. Scope

This Standard Operating Procedures (SOP) describes the methods and procedures to be followed in conducting a soil vapor survey. It provides the procedures for installing soil vapor sampling points and the methodology for sampling these points.

1.2. Rationale for Selection of Probe Location

Prior to performing the soil vapor survey, the location of the soil vapor points should be preliminarily located based on a grid system. These gridded points should be placed on a figure to take out to the site. The grid locations can be adjusted to better define the extent of detected constituents based on prior knowledge of the site or based on field results. The grid may also be modified to reflect site-specific features.

Similarly, modifications to the sampling procedure can be made based on field results. For example, if no constituents are detected, then field blanks between each sample could be eliminated until constituents are detected. The project manager should approve all changes to the procedures.

One soil vapor probe will be installed as a reference probe. This probe will be left in place for the length of the soil vapor survey for the purpose of collecting repeat measurements to assess reproducibility of the data as discussed in Section 4.0.

2. Soil Vapor Probe Installation

2.1. Equipment that is required for installation and sampling shall include:

1. 1/4" diameter shield points
2. Interconnecting nipples
3. Soil vapor sampler (including pumps, vacuum gauges and air flowmeters)
4. Vacuum desiccator
5. Tedlar® bags
6. Rotary hammer drills

7. Rubber mallet
8. Screw drivers, wrenches, and channel lock pliers
9. Pairs of lineman's gloves and ear protection
10. Utility knives
11. Extension cords
12. Purge pump with Tygon[®] tubing
13. Flat cleaning brushes
14. Rolls of Teflon tape
15. Ground fault circuit interrupters
16. Generator (if required)
17. Road boxes, concrete, bentonite grout (permanent installations)
18. Stop watch

2.2. Probe Installation Procedure

2.2.1. Safety Precautions

Locate the sampling point. If the location has not been checked for utilities by an authorized site official or "Call-Before-You-Dig", make arrangements to have this done before you proceed. Allow a minimum of 3 days for Call-Before-You-Dig to clearly mark all utility locations. Confirm that the site has been clearly marked. Site representatives should also be contacted to clear the area for the presence of utilities. If subsurface metal objects are likely to be present, a metal detector should be utilized for location identification.

To protect against electric shock when using the hammer drill, a Ground Fault Circuit Interrupter (GFCI) will be utilized. This device will automatically shut down the electric hammer drill when it senses a short.

As an added precaution when drilling in areas where there is a potential for drilling into live electrical wires, the hammer drill operator will wear insulated lineman's gloves to prevent the passage of an electric current up the drill and into the operator's body.

Eye and ear protection is required while operating the hammer drill. It is advised that hand protection also be worn when manipulating the soil augers on the electric hammer drill.

2.2.2. Drill Procedures

When restrictive layers or pavement surfaces are present, drill a pilot hole using a 1½" diameter solid auger prior to the insertion of the soil vapor

sampling probe. After attaching the auger, select the "hammer/drill" mode on the drill to commence augering.

Grasp the drill tightly while augering to offset the torque generated by the auger. Periodically retract the auger from the borehole to clean the cuttings from the flights. Once pilot hole augering has been completed, insert the stainless steel shield point and drive from four to six inches into the undisturbed soil (i.e. to the desired depth) using a rubber mallet. Mold a ball of clay or tight soil around the shaft where it intersects the ground surface to seal off the borehole.

Use dedicated probes for each sampling location. Alternatively, flush the vapor probe for 2-5 minutes with ambient air and collect a blank sample (ambient air) for on-site screening with the gas chromatograph. Dedicated probes should be used if the gas chromatograph is not available at the site.

2.3. Sampling Procedures

The procedure described below will be followed when low level contamination is expected (less than 10 ppm). A vacuum desiccator will be used when heavier contamination is suspected. A portable total VOC analyzer equipped with a PID or FID detector will be used to provide guidance.

2.3.1. Low-Contamination Levels Soil Vapor Surveying

Attach the tubing from the soil vapor sampler to the probe shaft. The soil vapor sampler includes a pump, two flowmeters for measuring high and low range flow rates, a vacuum gauge, and a needle valve for adjusting the flow. **The flowmeter readings should be converted to flow units using the conversion table provided with each instrument.**

Purge at least three times the volume of gas contained within the probe, tubing and soil vapor sampler. Do not purge excessively to avoid pulling air from the surface. Measure the air flow by observing the air flowmeter and using a stop watch. This can be measured by filling and emptying a Tedlar® bag a set number of times (say three times). Do not fill the Tedlar® bag to firmness at any time.

After sampling adjust and record the flow and vacuum on the soil vapor sampling equipment. Repeat this procedure at three different flow rates (maximum achievable, low, and mid-range). This information is useful in determining field intrinsic air permeabilities.

Once samples from all desired depths have been collected from the sample location, disconnect the soil vapor sampling equipment and remove the probe from the ground.

Leave soil vapor sampling pump on at high air flow between sampling locations to purge the instrument and tubing.

Move to the next soil vapor sampling location. After installing the next vapor probe (dedicated) in accordance with Section 2.2, collect an equipment blank prior to sampling at the new location. The equipment blank will be collected from the purged soil vapor sampling equipment using either a Tedlar[®] bag or a GC syringe. If the results of analysis of this blank shows no contamination, then the new soil vapor sampling location can be sampled as discussed above. If contamination is detected, continue purging and collecting equipment blanks until no contamination remains.

2.3.2. High-contamination Levels Soil Vapor Surveying

These procedures will be followed when highly contaminated vapor samples (greater than 10 ppm) are suspected.

Use the vacuum desiccator to collect the air samples to avoid contamination of the air sampling equipment. Check local air quality surrounding the sample collection point to ensure safe working conditions.

Attach the vacuum desiccator to the vapor probe using a 3/16" ID x 3/8" OD Tygon[®] tubing. Attach the tubing to the vacuum desiccator. Keep tube length as short as possible.

Attach 1/4" ID x 3/8" OD Tygon[®] tubing to the Tedlar[®] bag and the other end to the inside of the vacuum desiccator. Place the Tedlar[®] bag into the vacuum desiccator. Next, attach a length of 3/16" ID x 3/8" OD Tygon[®] tubing, approximately 4" long, from the vacuum desiccator to the air sampling equipment intake.

Turn on the air sampling equipment. The air sampling equipment should be set to pump at a maximum rate.

Purge system by filling and emptying the Tedlar[®] bag three times. Do not fill bag to firmness at any time. This is done to prevent stress cracks from forming and destroying the Tedlar[®] bag. Every time the bag is filled you must open the desiccator, remove the Tedlar[®] bag and then empty the bag. Afterward, place the bag into the vacuum desiccator again and continue these steps until the system is purged.

Collect the sample by filling the Tedlar® bag, being careful not to overfill.

Close the valve on the Tedlar® bag and remove the bag from the desiccator. Label bag and log in the field report.

3. Sample Analysis

Samples will be analyzed for volatile organic compounds (VOCs) with the LEA portable GC. The LEA portable GC will be operated in accordance with the LEA SOP for the Portable Gas Chromatograph (SOP #10002). Meters will be properly calibrated at the start of each day and periodically throughout the day in accordance with LEA SOPs or manufacturer specifications.

4. Quality Assurance/Quality Control (QA/QC)

To preserve sample integrity, all sampling equipment will be stored away from volatile organic vapors when not in use. To reduce the risk of cross-contamination, all equipment which comes in contact with the sample will be thoroughly purged or will be dedicated equipment.

Additional QA/QC checks include ambient air blanks and equipment blanks. A sampling location is selected which provides typical levels of contaminants observed at the site and repeat measurements at the reference probe installations (a minimum of twice daily) are performed in order to assure reproducibility of the data. Soil vapor data are recorded on customized data sheets and carefully reviewed on a daily basis.

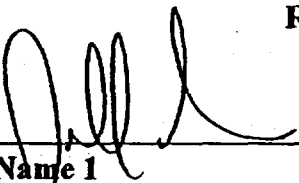
**Standard Operating Procedure
for
Geologic Logging of Unconsolidated Sedimentary Materials**

SOP ID: 10015

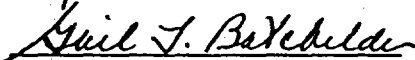
Date Initiated: 12/27/94

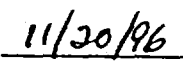
Revision #001: 11/20/96

Approved By:


Name 1


Date


Name 2


Date

REVISION RECORD

<u>Rev #</u>	<u>Date</u>	<u>Additions/Deletions/Modifications</u>
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**Standard Operating Procedure
for
Geologic Logging of Unconsolidated Sedimentary Materials**

1. Statement of Purpose

This document presents the methods and procedures used to describe unconsolidated sedimentary materials for geological purposes in a uniform and consistent manner. It includes procedures for properly recording the observations by providing guidelines for completing boring logs and submitting those logs for computer entry. This Standard Operating Procedure (SOP) refers only to geologic logging of soils and sediments (including artificial fill and other man-made deposits) and specifically is not intended to describe logging of soils or sediments for geotechnical or other engineering purposes. Although the SOP presents a system for describing sediments, it is not intended to be a definitive reference for classifying sedimentary materials, nor is it intended to replace experience or training. Individuals using this SOP should be trained and competent in field methodologies and geologic logging prior to commencing field activities.

2. Collection of Unconsolidated Soil/Sediment Samples

2.1. Equipment required for the geologic logging of soil/sediment samples shall include the following items:

- Tape measure or scale
- Hand lens
- Color chart
- Grain-size comparator
- Field forms
- Indelible marker(s)
- Small table
- Field Book
- Clipboard

2.2. Sample Collection

Samples of soil and unconsolidated sedimentary materials will be collected in general accordance with the SOPs for Soil Sampling (SOP #10006), Hand Auger Borings (SOP #10003), Hollow Stem Auger Soil Borings (SOP #10008), and Geoprobe® Probing and



Sampling (SOP #10011). Those SOPs include procedures for decontamination of equipment required for sample collection, as well as providing the methodologies for sample collection and documentation.

3. Descriptions of Unconsolidated Sedimentary Materials

3.1. General Sediment Description Guidelines

For the purposes of geologically logging unconsolidated soils and sedimentary materials, a Modified Burmister method of description and classification should be used. The Modified Burmister Sediment Classification System (or simply, Burmister System) is intended as a rapid field method for identifying and classifying sediments. The system is based upon visual identification of the generalized grain-size distribution and description of the physical characteristics of the sample.

A Burmister System description is comprised of three parts: a color descriptor; a grain-size descriptor; and modifier(s).

The color descriptor indicates the overall color or colors of the wet sample. The descriptor consists of a color name or names and (if possible) the color code from a standard color reference (for example, a Munsell⁷ Color Chart).

The grain-size description indicates the predominant grain size in the sample, as well as the relative percentages of other grain sizes present.

Modifiers are used to further describe the geologic character of the sample. Modifiers may include descriptions of moisture content, sorting, sphericity, angularity, sedimentary structures or other pertinent information.

3.1.1. Color Description

The color of the wet sediment should be determined with reference to a standard color comparator (for example, a Munsell⁷ Color Chart) for rocks or sediment. The included color descriptor should contain both the color name and, when a color comparator is used, the appropriate hue-chroma value code, for example "Reddish brown (5YR 4/4)". The color of a sample should always be gauged when the sample is wet, or it should be noted otherwise.

3.1.2. Predominant Grain-Size Description

The first step in describing a sediment sample is visually estimating the size range and percentage of the various grain sizes in the sample.

Reference should be made to standard geologic comparators for assessment of the grain size(s).

The primary grain-size descriptor indicates the predominant grain size, as judged visually, of the sample. The descriptor is always capitalized and underlined. Possible descriptors include: CLAY, SILT, SAND, GRAVEL (GRANULES, PEBBLES, COBBLES, and BOULDERS). These correspond to the standard Wentworth size-classification scheme used for describing sediments for geologic purposes. Size classifications for CLAY through GRAVEL are presented in Table 1. The descriptor should also include an indication of the relative size range of the sample within the predominant grain size (for example, "fine-to-medium sand", "coarse sand", etc.). Although Table 1 includes divisions of the silt category, this is applicable only to sediment samples analyzed by pipette or hydrometer and cannot be distinguished in the field.

The presence of other grain sizes, in addition to the predominant material is also included in the grain-size descriptor. Appropriate grain sizes are the same as for the predominant grain size of the material (clay, silt, etc.), however only the initial letter of the word is capitalized. The description should also include an indication of the relative amount of the minor components. Appropriate indicators for the relative percentages present are provided in Table 2.

It is generally not considered possible to visually distinguish between clay and silt. Estimation of the silt/clay content of a sample should be based upon the plastic properties of the sample. The plastic properties of the sample may be estimated by taking an approximately 1 cubic centimeter ball of the sediment and attempting to roll a thread of the material between the palms of the hand. The minimum size of the thread which may be rolled may be compared to the values presented in Table 3 and the plasticity estimated. A comparison of the minimum thread diameter which may be formed with the information presented in Table 3 provides an approximate silt/clay content estimate for sand-silt-clay sediments and composite clay sediments.

3.1.3. Modifiers

Various modifiers may be added to the basic sediment description to further describe the geologic character of the sample.

For sand or coarser-sized material, the relative degree of sorting, the sphericity, and angularity should also be recorded. Sorting may be visually estimated. Sphericity and angularity, however, should be made with reference to an accepted comparator. A chart illustrating various degrees of sphericity and angularity is attached as Figure 1.

The mineralogy of the sample should also be recorded. Reference should be made to the relative percentages, grain size(s), and sphericity of the mineral particles (especially where it differs significantly from that of the predominant grain-size material).

Other information which should be recorded for each sample includes an estimate of the density and cohesiveness of the sample (made from blow counts where applicable, or other specific instrumentation where appropriate), the relative moisture content of the sample, visible sedimentary structures, and any odors or staining noticeable during logging. Tables 3 and 4 present appropriate terms for describing the plasticity, density, and cohesiveness of sediment samples.

Especially important is an indication that a specific portion of the material may represent "sluff" or material collapsed from the borehole walls.

3.2. Written Sediment Descriptions

The written sediment description may be made as either an unabbreviated or an abbreviated description. Both methods should relate the same information, however the abbreviated description is better suited for field use.

In an unabbreviated description, all of the words of the description should be written out in their entirety. The descriptor should include pertinent information regarding the sample's size gradation, consistency, color, and relative grain size, as described previously. The color descriptor should precede the primary sediment component name, while additional details such as the plasticity, mineralogy, visible sedimentary structures, etc., should follow the sediment component name.

An example of an unabbreviated description is:

Red-brown (5YR 4/4), fine to coarse SAND, little fine Gravel, little Silt, moist, moderately well sorted, low



sphericity, Gravel waterworn, Sand subangular, micaceous.

Since the Burmister system is intended to provide a means for describing uniform sediments, three "special" cases should be addressed.

First, the Burmister system is intended only to describe the sediment. Where a genetic classification of the material is significant, it should be added as a separate statement at the end of the description. For example:

Olive gray (5Y 4/2), coarse to fine SAND, some fine Gravel, little Silt, moist, poorly sorted, sub-rounded to angular, dense. TILL.

A genetic classification should only be used when the origin of the material is very clear and not simply a field interpretation of possible depositional environment.

Second, in the case where the sediment sample is heterogeneous (for example, a varved silt and clay), each component should be described individually, and reference should be made to the relative percentages of each component and to the interlayering. For example:

Soft, reddish-brown (5YR 3/4), CLAY and SILT, alternately layered, medium to high overall plasticity. Layers: CLAY layers, 3/8" to 5/8" thick, comprise 60%" of sample. SILT layers, 1/8" to 3/8" thick, comprise 40%" of sample. VARVED CLAY and SILT.

Third, when one material grades uniformly into a distinct sediment type, the individual components should be described separately and the gradation noted. For example:

Soft, reddish-brown (5YR 3/4), CLAY, medium overall plasticity, grading into soft, reddish-brown (5YR 4/4), SILT, trace Clay, low overall plasticity.

In the abbreviated sediment descriptions, the sample information is presented in a manner analogous to that for the unabbreviated description substituting standard abbreviations for specific portions of the text. Abbreviations for the identifying terms in the Burmister system are presented in Tables 2, 3, and 4. Mineralogic

and geologic abbreviations may be found in standard geologic and mineralogic texts and field manuals. Except for the use of abbreviations, the abbreviated description is completely analogous to the unabbreviated description.

For the sake of consistency in describing unconsolidated sedimentary materials, the description should follow the order and general definitions presented in Table 5.

4. Recording Descriptions

4.1. Geologic Boring Logs

Attached to this SOP is a copy of LEA's standard geologic boring log form. This log should be completed for each boring that is completed. The heading information is self-explanatory. The body of the log contains space for information for each sampled interval in the boring. The following information should be recorded:



Depth Interval	The upper and lower depths from which the sample was collected.
Sample No.	The sample number, as obtained from LEA Data Management, assigned to this sample.
Recovery	The length of the recovered sample and the length of the sampler (in consistent units). The percent recovery will be calculated by the geologic logging program.
Blows/6"	The number of blow counts per 6" interval for the sample. Alternately, the downhole pressure or other pertinent information regarding the required drilling or sampling force.
Sample Description	The sample description using the guidelines and order presented in Section 3.0 and Table 5.
PID/FID	The headspace reading from a PID or FID in ppm.

The comments section of the form should be used to record general observations regarding drilling conditions, backfilling of the borehole, or other pertinent information regarding drilling the borehole.

4.2. Computer Data Entry

After a project is completed, copies of the Geologic Boring Log forms should be submitted for computer data entry. A completed copy of the Geologic Soil Boring/well Completion Log Request Form should be attached to the log forms; a copy of the request form is attached to this SOP.

TABLE 1
Wentworth Size Classification System

US Standard Sieve Sizes	Millimeters	Microns	Phi (N)	Wentworth Size Classification	
Use Wire Squares	4096	4,096,000	-20	Boulder	GRAVEL
	1024	1,024,000	-10		
	256	256,000	-8		
				Cobble	
	64	64,000	-6		
				Pebble	
	16	16,000	-4		
5	4	4,000	-2		
				Granule	
6	3.36	3,360	-1.75		
7	2.83	2,830	-1.50		
8	2.38	2,380	-1.25		
10	2.0	2,000	-1.00		
				Very Coarse Sand	SAND
12	1.68	1,680	-0.75		
14	1.41	1,410	-0.50		
16	1.19	1,190	-0.25		
18	1.00	1,000	0.00		
				Coarse Sand	
20					



	0.84	840	0.25	
25	0.71	710	0.50	
30	0.59	590	0.75	
35	0.50	500	1.00	
				Medium Sand
40	0.42	420	1.25	
45	0.35	350	1.50	
50	0.30	300	1.75	
60	0.25	250	2.00	
				Fine Sand
70	0.210	210	2.25	
80	0.177	177	2.50	
100	0.149	149	2.75	
120	0.125	125	3.00	
				Very Fine Sand
140	0.105	105	3.25	
170	0.088	88	3.50	
200	0.074	74	3.75	
230	0.0625	62.5	4.00	



					Coarse Silt	MUD
270	0.053	53	4.25			
325	0.044	44	4.50			
Analyzed by Pipette or Hydrometer	0.037	37	4.75			
	0.031	31	5.0			
					Medium Silt	
	0.0156	15.6	6.0			
					Fine Silt	
	0.0078	7.8	7.0			
					Very Fine Silt	
	0.0039	3.9	8.0			
					Clay (Note: Some use 2: (or 9N) as the clay boundary.)	
	0.0020	2.0	9.0			
	0.00098	0.98	10.0			
	0.00049	0.49	11.0			
	0.00024	0.24	12.0			
	0.00012	0.12	13.0			
	0.00006	0.06	14.0			



Table 2
Modified Burmister System Descriptors

Fractions		Proportion Descriptors		
(+)	Major Fraction	Quantity	Descriptor	Abbreviation
(-)	Minor Fraction	35% - 50%	and	a
e.g., a medium to coarse SAND which is predominantly medium grained would be written as: m(+)-c <u>SAND</u>		20% - 35%	some	s
		10% - 20%	little	l
		1% - 10%	trace	t
		Modifiers: (+) Upper a of the range (-) Lower a of the range		

Table 3
Plasticity of Sediment Samples

Material	Symbol	Feel	Ease of Rolling Thread	Minimum Thread Diameter	Plasticity Index	Plasticity
Clayey SILT	CyM	Rough	Difficult	1/4"	1 to 5	Slight (SI)
SILT & CLAY	M & C	Rough	Less Difficult	1/8"	5 to 10	Low (L)
CLAY & SILT	C & M	Smooth, dull	Readily	1/16"	10 to 20	Medium (M)
Silty CLAY	MyC	"Shiny"	Easy	1/32"	20 to 40	High (H)
CLAY	C	Waxy, very shiny	Easy	1/64"	40 +	Very High (VH)

Table 4
Density and Cohesiveness of Sediment Samples

Density of Cohesionless Soils		Consistency of Cohesive Soils	
Blow Counts	Relative Density	Blow Counts	Consistency
0 to 4	Very Loose	0 to 2	Very Soft
5 to 9	Loose	2 to 4	Soft
10 to 29	Medium Dense	4 to 8	Medium
30 to 49	Dense	8 to 15	Stiff
50 to 79	Very Dense	15 to 30	Very Stiff
80 or more	Extremely Dense	30 or more	Hard

Table 5
Description of Sediment Properties

Sediment Parameter	Properties
Color	The color of the sample should be described for the wet sediments. If possible the color should be referenced to a standard color chart such as a Munsell7 Color Chart.
Primary Grain Size	Primary grain size refers to the size of the predominant sedimentary size class within the material (as judged visually). The grain size divisions should conform to the standard Wentworth Scale divisions, as shown in Table 1.
Secondary Grain Size(s)	Secondary grain size(s) refer to material which, as a grain-size group, comprises less than the majority of the sediment. Aside from stating the size classification, the relative percentage of the material must be stated. The grain size divisions should conform to the standard Wentworth Scale divisions as shown in Table 1. To describe the approximate percentage of the secondary grain size(s) present, qualifiers shown in Table 2 should be used.
Moisture Content	The moisture content of the sample should be described as dry, slightly moist, moist, or wet. Gradation from one state to another should be recorded as, for example, moist to wet, or moist ½ wet.
Sorting	The relative degree of sorting of the sediment should be indicated as poor, moderate, good, or very good. The degree of sorting is a function of the number of grain size classes present in the sample; the greater the number of classes present the poorer the sorting. In addition, for samples composed only of sand, the relative degree of sorting is a function of the number of sand-size subclasses present.
Sphericity	Sphericity is a measure of how well the individual grains, on average, approximate a sphere. The average sphericity of the sand and larger size fractions should be described as low, moderate or high. A chart illustrating various degrees of sphericity is presented in Figure 1.
Angularity	Angularity, or roundness, refers to the sharpness of the edges and corners of a grain (or the majority of the grains). Five degrees of angularity are shown in Figure 1: Angular (sharp edges and corners, little evidence of wear); Subangular (edges and corners rounded, faces untouched by wear); Subrounded (edges and corners rounded to smooth curves, original faces show some areas of wear); Rounded (edges and corners rounded to broad curves, original faces worn away); and, Well Rounded (no original edges, faces, or curves, no flat surfaces remain on grains).
Sedimentary Structures	Sedimentary structures are such things as varved layers, distinct bedding, or stratification.
Density -or- Cohesiveness	The density of cohesion of a sample (for the purposes of this application) refer to the sample's resistance to penetration by a sampling device. Density is used in reference to sediments primarily silt-size and coarser while cohesiveness is used in reference to primarily clay-sized sediments. Density or cohesiveness can be assessed from the number of blows from "standard" split-spoon sampling (i.e., 140# hammer, 30" fall, 2" X 2" (O.D., 1 3/8" I.D.)) split-spoon samplers according to the scale in Table 3.

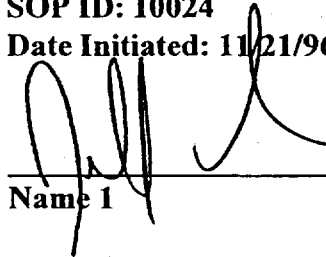


**Standard Operating Procedure
for
Geoprobe® Screen Point Groundwater Sampling**

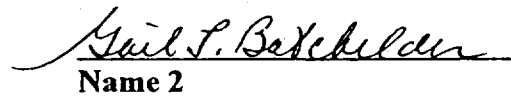
SOP ID: 10024

Date Initiated: 11/21/96

Approved By:


Name 1

11/21/96
Date


Name 2

11/21/96
Date

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure
for
Geoprobe® Screen Point Groundwater Sampling

1.0 Statement of Purpose

This standard operating procedure (SOP) has been prepared to describe the methods and procedures to be used to collect groundwater samples using the Geoprobe® Screen Point Groundwater Sampling device.

The techniques and procedures are adapted from the Geoprobe Systems Technical Bulletin 94-440, dated April 1994. Techniques and procedures associated with operation of the Geoprobe® and the collection of soil samples using Geoprobe® methodologies are presented in the SOP entitled, *Standard Operating Procedures for Geoprobe® Probing and Sampling*.

2.0 Required Equipment

The following equipment is required to collect samples of groundwater using the Geoprobe® Screen Point Sampling Methodologies.

<u>Screen Point Sampler Parts</u>	<u>Part Number</u>
Groundwater Sampler Drive Head	GW-430B
O-Ring for Groundwater Sampler Drive Head	GW-430R
Screen Point Sampler Sheath	GW-440
Drive Point Seat	GW-440-1
O-Ring for Drive Point Seat	GW-440-1R
Screen Sleeve	GW-441
Screen Connector with PRT-Adapter Threads	GW-443
O-Ring for Screen Connector	GW-443R
Screen Insert and Plug (Assembled Unit)	GW-444
O-Ring for Screen Plug	GW-444R
Expendable Drive Point	GW-445
O-Ring for Drive Point	GW-445R
Screen Connector Pin	GW-446
Screen Connector Pin Punch	GW-447

<u>Geoprobe® Tools</u>	<u>Part Number</u>
Probe Rod (4 Foot)	AT-104B
Probe Rod (3 Foot)	AT-10B
Probe Rod (2 Foot)	AT-105B
Probe Rod (1 Foot)	AT-106B
Drive Cap	AT-11B
Pull Cap	AT-12B
Extension Rod	AT-67
Extension Rod Coupler	AT-68
Extension Rod Handle	AT-69

<u>Optional Equipment</u>	<u>Part Number</u>
Tubing Bottom Check Valve	GW-42
Check Balls for Check Valve	GW-42-1
Polyethylene Tubing, 1/4" ID	TB-251
Probe Rod Pull Plate	AT-122
PRT Fitting	PR-25S or PR-30S

3.0 Procedures and Guidelines

Procedures referred to in this section refer specifically to those Geoprobe® operations associated with the use of the screen point sampler. All other Geoprobe® operations are described in the SOP entitled *Standard Operating Procedures for Geoprobe® Probing and Sampling*.

3.1 Basic Operation

The outer appearance of the Screen Point Groundwater Sampler, once it has been assembled properly, looks just like a normal Geoprobe® 3-foot probe rod. The bottom is fitted with an expendable drive point, while the top of the sampler can be connected to Geoprobe® rods and other accessories. The assembled sampler can be driven either hydraulically by any Geoprobe® Model 5400 machine, manually using drilling machines, or by using cone penetrometers.

At sampling depth the probe rods attached to the sampler are retracted two feet to allow the sampler screen to be pushed out into the formation.

3.2 Assembly

- Push the screen insert and plug (GW-444) equipped with an O-ring (GW-444R) into the screen sleeve (GW-441) which is the end of the screen sleeve with only one drain hole.
- Push the screen connector (GW-443), which is fitted with an O-ring (GW-443R) over the top of the screen sleeve and secure with the connector pin (GW-446). The pin can easily fall out since it is a rather loose fit.
- Insert the screen connector end of the assembled screen halfway into the screen point sampler sheath (GW-440) from either end. Again, the screen connector end is inserted first.
- Slide the drive point seat (O-ring GW-440-1R) over the protruding end of the screen sleeve and screw it tightly into the sampler sheath.
- Push the screen sleeve up into the sampler sheath just far enough to fit the expendable drive point (O-ring GW-445R) into the bottom end of the drive point seat.
- Screw the O-ring end of the water sampler drive head (GW-430B) into the top of the sampler sheath. Make sure all threads are fastened tightly.

3.3 Probing

- Drive the water sampler approximately two feet below the depth level where you want to sample by attaching it to the Geoprobe® rods.
- Never drive the water sampler without the O-ring (GW-445R) attached to the drive point. Failure to use this O-ring may result in flowing soils clogging the screen during driving.

3.4 Screen Deployment

Once the screen point sampler has been driven to the base of the interval desired for sampling, the probe rods are retracted a distance of two feet and the screen is pushed out into the formation. The following procedures should be used:

- Retract the probe rods from the ground a distance of two feet.

- Insert Geoprobe® stainless steel extension rods (AT-67) down the bore of the probe rods. An extension rod coupler (AT-68) must be placed at the bottom end of the lead extension rod in order to protect the threads at the end of this rod. One extension rod will be required for each probe rod in the ground, plus one extension rod for the screen point sampler itself. Place an extension rod handle (AT-69) at the top of the extension rod string.
- When the proper number of extension rods have been coupled together and inserted down the bore of the probe rods, the last extension rod will protrude from the top of the probe rods a distance of approximately 24 inches.
- Pushing down on the extension rods should now push the screen out into the formation. When the screen is completely pushed out, the extension rod handle will come to rest at a final position approximately 3 inches above the top of the probe rods.
- In extreme situations, it may be necessary to tap on the top of the extension rod handle with a hammer in order to force the screen out into the formation.

3.5 General Sampling Considerations

There are two methods for obtaining a sample from the GW-440 series screen point sampler. Groundwater samples can be obtained by bailing or pumping directly from the bore of the probe rods above the screen point. Alternately, a tubing system may be attached directly to the top of the deployed screen and samples pumped to the surface using either a peristaltic pump or other means of vacuum lift.

3.6 Bottom Check Valve Sampling

The most common groundwater sampling method employed is to pump directly from the bore of the probe rods immediately above the screen point using a tubing bottom check valve. This method is often referred to as "sampling from the open rods," and is essentially the same for bottom check valve sampling as it is for bailing. Note that in order for this method to be employed, the piezometric head in the saturated formation must be above the top of the deployed screen point; water from the formation must rise into the probe rods where it can then be pumped to the surface. Sampling is performed as described in the following steps.

- Either 3/8-inch OD Teflon® (TB-30T) or polyethylene (TB-25L) tubing may be used for groundwater sampling. Selection of tubing material should be based on the analytes of interest and the purpose of the groundwater investigation.
- Place a tubing check valve (GW-42) at the bottom end of a roll of tubing. This bottom check valve will fit either of the tubing types listed above.
- Push the tubing, check valve end first, down the bore of the probe rods until it strikes the top of the screen point sampler.
- Lift the tubing approximately 4 inches off the bottom (top of the screen point sampler) and oscillate the tubing up and down in 8-inch to 12-inch strokes. In field practice, the tubing is oscillated up and down by hand at a rate of 60 to 100 strokes per minute. This pumping can yield as much as 500 milliliters of sample per minute.
- Air bubbles appearing in the pumped stream indicate that the pumping action is exceeding recharge from the screen point, allowing air to enter at the check valve end. For most purposes, intermixing of air with the pumped sample is undesirable. The pumping rate should be slowed and balanced with the recharge rate.
- If water cannot be pumped to the surface, sufficient sample may be obtained by using the tubing and check valve as a bailer. Oscillate the tubing to fill it with several feet of sample and then remove the tubing from the rods.

3.7 Sampling Through PRT Tubing

"PRT" (post run tubing) refers to a Geoprobe® proprietary system of tubing and fittings that are used both for vapor and groundwater sampling. This tubing is inserted down the rods after the sampler has already been driven to depth and has been deployed for sampling. The top of the screen point sampler is equipped with a PRT fitting which serves as a receptacle for a corresponding PRT adapter fitted onto the end of the sampling tube.

In practice, the tubing with the PRT adapter at the lower end is inserted down the bore of the probe rods and screwed into the receptacle on the top of the sampler screen. This procedure forms a vacuum-tight sample train from the sampler screen to the ground surface. Sample is normally pumped to the surface using a peristaltic pump or other vacuum source.

The advantage of this method is that the sample is only placed in contact with the stainless steel sampler screen and tubing. The sample is never exposed to a free surface. The

disadvantage of this method is that it is limited to maximum groundwater depths of 20 to 28 feet below ground surface.

The following procedures are used to obtain groundwater samples using PRT fittings and tubing.

- Either 3/8-inch OD Teflon® (TB-30T) or polyethylene (TB-25L) tubing may be used for groundwater sampling. Selection of tubing material should be based on the analytes of interest and the purpose of the groundwater investigation. Each of these tubings has a corresponding PRT adapter that is required for this sampling. These adapters are shown in the following table:

<u>Tubing and PRT Adapters</u>		
<u>Tubing</u>	<u>Description</u>	<u>PRT Adapter Part Number</u>
TB-30T	3/8-inch Teflon®	PR-30S
TB-25L	3/8-inch Polyethylene	PR-25S

- Place the barbed end of the appropriate adapter into the selected tubing.
- Push the adapter end of the tubing down the bore of the probe rods until it comes into contact with the PRT threads at the top of the screen point sampler.
- Rotate the tubing counter-clockwise at the surface to screw the adapter into the screen point threads. Rotate the tubing several revolutions until the downhole adapter is completely seated and the tubing starts twisting. In this condition, the tubing will rotate backwards (clockwise) when released.
- The tubing can now be attached to a peristaltic pump or vacuum source at the surface.
- After sampling is complete, tubing should be removed by pulling it up at the surface. This will pull the tubing off the barbed end of the tubing adapter and will allow the operator to examine the connection at the top end of the screen point when it is pulled from the ground.

3.8 Sampler Removal and Retrieval

- Remove all sampling tubes from the bore of the probe rods.

- Pull all rods from the ground using the Geoprobe® machine. Care should be taken not to push down on the probe rods during removal.
- Care should be taken to lift the screen point sampler vertically upward at the surface. Pulling the probe rods or sampler from the ground at any direction other than vertical may result in bending of the screen point sampler.
- Dismantle the sampler at the surface and examine it for damage. Decontaminate all parts, replace all O-rings, and re-assemble the sampler for the next sample.

4.0 Sample Handling

All groundwater samples collected by the methods and procedures presented above will be treated exactly as any other groundwater sample. The sample will be handled in general accordance with the procedures and guidelines described in the LEA SOP entitled *Standard Operating Procedure for Liquid Sample Collection and Field Analysis*. However, because of the nature of the screen point sampling method, it is not necessary to attempt to "purge" a screen point sampler or to attempt to stabilize the field parameters prior to collecting the sample.

5.0 Equipment Decontamination

All sampling equipment used to collect groundwater samples must be clean and free of any potential contaminants. In general, the choice of decontamination procedures should be based upon a knowledge of the site-specific contaminants and outlined in the site-specific work plan.

For sites at which the contaminants are unknown, but contamination is suspected, the decontamination procedures outlined below should be followed.

- Prior to commencing any field activities, the following solutions will be prepared and placed into 500-ml laboratory squirt bottles: methanol (<10% solution) in water; 10% nitric acid; 100% n-Hexane; distilled, de-ionized water.
- In the field, prepare approximately 2.5 gallons of a solution of Alconox® (or other suitable non-phosphate laboratory grade detergent) in tap water in a 5-gallon bucket.
- Prepare a piece of 5-mil polyethylene sheeting to underlie the decontamination area. The sheeting should be of sufficient size to contain any accidental discharge of decontamination solutions. The edges of the sheeting should be bermed to contain spills.
- The order for decontaminating equipment is as follows:
 - 1) Detergent Scrub;
 - 2) DI Water Rinse;
 - 3) Hexane Rinse;
 - 4) DI Water Rinse;
 - 5) 10% Nitric Acid Rinse;
 - 6) DI Water Rinse;

7) Methanol (<10% solution) Rinse;

8) Air Dry.

- Wrap each piece of decontaminated equipment in aluminum foil to maintain cleanliness.
- At the end of the project day, all spent decontamination fluids and materials such as the polyethylene sheeting and personal protective equipment will be disposed of in accordance with all applicable municipal, state, and federal regulations.

**Standard Operating Procedure
for
SW-846 Method 8021
Analysis of Volatile Organic Compounds
by Purge and Trap Gas Chromatography**

SOP ID: 10026

Date Initiated: 3/17/97

Revision #000

Approved by: Christina M. Clemmey 9/30/97
Name 1 Date
AS Galan 9/30/97
Name 2 Date

REVISION RECORD

<u>Rev #</u>	<u>Date</u>	<u>Additions/Deletions/Modifications</u>
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1. Statement of Purpose

This Standard Operating Procedure (SOP) describes procedures for the operation of the SRI® model 910 gas chromatograph for detection of volatile organic compounds using SW-846 Method 8021-Purge and Trap Gas Chromatography. A list of compounds included in this method is presented in Table 1.

2. Scope and Application

2.1. Method Summary

Volatile organic compounds are separated using the SRI® Model 910 gas chromatograph equipped with a suitable capillary column and optimal temperature/pressure programs. Detection is achieved using a photoionization detector (PID) and a dry electrolytic conductivity detector (DELCD) in series. Computer acquisition and integration is achieved using Peaksimple II for windows software.

2.2. Sample Types

This SOP is applicable to nearly all types of samples including the following: groundwater, soil, sediments and vapor samples.

2.3. Injection Technique

Samples can be analyzed using direct injection or by purge and trap (EPA SW846 Method 5030).

2.3.1. Purge and Trap

Low-concentration contaminated soils and sediments should be analyzed using purge and trap. Medium-concentration soils or sediments may require methanolic extraction, as described in Method 5030, prior to purge and trap analysis. All groundwater samples must be analyzed by purge and trap (Method 5030).

2.3.2. Direct Injection on Column

In certain applications (e.g., aqueous process wastes) direct injection of the sample into the GC system with a 10 µl syringe may be appropriate. The detection limit for direct injection is very high (approximately 10,000 µg/l), therefore only when concentrations in excess of 10,000 µg/l

are expected or for water-soluble compounds that do not purge should direct injection be used. The system must be calibrated by direct injection.

2.4. Detection of Non-Halogenated Organics (SW-846 Method 8015)

This method has been adapted for analysis of Method 8015 compounds - diethyl ether, ethanol, methyl ethyl ketone (MEK), and methyl isobutyl ketone (MIBK). If Method 8021 is used for the above non-halogenated compounds, it must be made clear in the reporting of their results that analysis was performed by Method 8021.

3. **Reference**

- 3.1. EPA SW-846 Third Edition, Method 8021, Revision 1, September 1994.
- 3.2. Region I *Laboratory Data Validation Functional Guidelines For Evaluating Organic Analyses*. Hazardous Site Evaluation Division, USEPA and Viar and Company, November 1988.

4. **Sample Collection, Preservation, And Storage**

The information provided in this section is not intended to replace experience or training. Individuals using this SOP should be appropriately trained, qualified personnel.

4.1. **Sample Collection**

All samples (liquids, solids, semi-solids) must be introduced into respective sample containers gently to reduce agitation which might drive off volatiles.

- 4.1.1. Samples should never be collected near a running motor or any type of exhaust. Discharged fumes may contaminate the samples. Cross contamination may be prevented by sealing sample vials from each location in separate plastic bags.
- 4.1.2. Liquid samples should be poured into clean, dry 40 ml EPA VOA vials, with Teflon®-lined septum caps. No air bubbles should be introduced within the vial while filling. Should bubbling occur as a result of violent pouring, the vial must be emptied and refilled. Each VOA should be filled until there is a meniscus over the lip of the vial. The screw top lid with septum (Teflon® side towards the sample) should then be tightened onto the vial. After tightening the lid, the vial should be inverted and tapped to check for air bubbles. If any air bubbles are present, the sample must be retaken.

4.1.3. Solid and semi-solid (sludges) matrices should be packed into glass jars as best as possible. The vials should be tapped slightly as they are filled to eliminate as much free air space as possible.

4.2. Preservation

Preserve sample with HCl to a pH <2. Add approximately 2-3 drops HCl.

4.3. Chain-of-Custody

All samples should be labeled immediately after the VOA vial is filled and logged onto a chain-of-custody form. The field sample collector is personally responsible for the care and custody of the samples until they are relinquished to the laboratory.

4.4. Trip Blank

VOA samples may become contaminated by diffusion of volatiles organics through the septum during shipment and storage. To monitor possible contamination, a trip blank prepared from distilled deionized water should be carried throughout the sample, storage, and shipping process.

4.5. Sample Storage

Samples must be stored at 4°C.

4.6. Holding Time

Holding time for an unpreserved sample is seven days from date of collection.
Holding time for a preserved sample is fourteen days from date of collection.

5. Apparatus and Materials

SRI® Model 910 gas chromatograph.

Buck Model 8690-0051 EPA style purge and trap apparatus.

Analytical Column: MXT-VOL, 0.53 mm i.d., 60 meters, 3 microns, fused silica capillary column.

Detectors: Photoionization detector and Dry Electrolytic Conductivity detector.

Carrier Gases: Helium, Hydrogen

Volumetric flasks: assorted sizes, 10 ml to 500 ml.

Volumetric pipettes: various sizes.

Syringes: Gas tight micro-syringes, various sizes

40 ml EPA VOA vials

GC septa - shimadzu style, Restek corp.

Latex safety gloves

Safety glasses

Alconox or Liquinox laboratory detergent

Laboratory refrigerator

Analytical balance

Computer equipped with Windows 3.0 or higher and PeakSimple for Windows software

Printer

6. Reagents

6.1. Reagent Water

ASTM Type II quality or better [Type I]. Water must be free of organic compounds and have a maximum electrical conductivity of 1.0 $\mu\text{mho/cm}$ at 25°C.

6.2. Pesticide grade methanol

6.3. Stock standards

Prepared from pure (neat) standard materials or purchased as certified solutions.

7. Preparation Of Standards

7.1. Stock Standards

Stock solutions may be prepared from pure standard materials or purchased as certified solutions. Prepare stock standards in methanol using the assayed liquids,

solids, or gases as appropriate. Preparation of standards must occur in a fume hood. Refer to Method 8021 Section 55.

7.1.1. Stock standards should be stored with minimal headspace, at -10°C to -20°C and protected from light.

7.2. Secondary Dilution Standards

Prepare secondary dilution standards from stock standards or certified solutions in methanol. Generally, concentrations of 2.5 to 10 ng/ul for each component will be sufficient such that the aqueous calibration standards will bracket the working range of the analytical instrument. The volume in ul of stock standard needed is calculated. After this volume is added to a 10 ml volumetric flask containing approximately 9.5 ml methanol, the flask is filled to volume with methanol.

7.2.1. Secondary dilution standards are transferred to an appropriate size screw cap vial and stored at -10°C, away from light.

7.2.2. These standards should be checked frequently for signs of degradation or evaporation.

7.3. Calibration Standards

Calibration standards are prepared in reagent water from the secondary dilution of the stock standards at a minimum of five concentration levels. One of the concentration levels should be at or near, but above, the method detection limit. The remaining concentration levels should correspond to the working range of the GC. Each standard should contain each analyte for detection by this method. See Table 1 for a list of compounds included in this method. Some or all of these compounds may be included. In order to prepare accurate aqueous standard solutions, observe the following precautions and procedures:

7.3.1. Fill a 5 ml syringe with organic free reagent water.

7.3.2. Using a microsyringe, extract the desired volume of a secondary dilution standard. Do not inject more than 20 µl of an alcoholic standard into 100 ml of water.

7.3.3. Rapidly inject the alcoholic standard into the filled syringe and remove the needle as fast as possible after injection.

7.3.4. Aqueous standards are not stable and should be discarded after 1 hour, unless properly sealed and stored. Aqueous standards can be stored up to 24 hours, if held in sealed vials with zero headspace.

7.4. Surrogate Standards

Surrogate standards are used to monitor both the performance of the analytical system and the effectiveness of the method in dealing with each sample matrix. Every sample, reagent water blank and standard is spiked with 2-bromochlorobenzene and 1,4-dichlorobutane.

7.4.1. Prepare a secondary dilution of the surrogate stock standard to a final concentration of 15 ng/ml in reagent water. Add 10 μ l of the 15 ng/ μ l surrogate spiking solution directly into the 5 ml syringe with every sample and reference standard.

7.5. Internal Standards

An internal standard, 2-bromo-1-chloropropane, is added to every standard, sample, and blank to ensure that the sensitivity and response is stable in every run.

7.5.1. Prepare a secondary dilution of the internal standard stock standard to a final concentration of 15 ng/ μ l in reagent water. Add 10 μ l of the internal standard solution directly into the 5 ml syringe with every sample and reference standard.

7.6. Surrogate

Standard/Internal Standard Spiking Solution: The surrogates and internal standards may be combined and added to all standards, samples and blanks as a single spiking solution. Prepare a secondary dilution spiking solution as described in Sections 7.4.1 and 7.5.1.

7.7. Matrix Spike Standards

Matrix spikes and matrix spike duplicates are used to determine long-term accuracy and precision of the analytical method on various matrices. A matrix spike and matrix spike duplicate is performed approximately once per matrix, or every 20 samples, whichever is greater. Matrix spike stock standards and secondary dilution standards may be prepared from calibration standards or from quality control samples. A volume is injected into the 5 ml luerlock syringe with the sample. See Table 2 for compounds contained in matrix spike mixture and QC acceptance criteria for matrix spike samples.

8. Interferences

8.1. Carryover Contamination

Contamination by carryover can occur whenever high-level and low-level samples are sequentially analyzed. To reduce carryover, the sample syringe or purging device must be rinsed out between samples with water or solvent. Whenever an unusually concentrated sample is encountered, it should be followed by an analysis of a solvent blank or of water to check for cross contamination. For volatile samples containing large amounts of water-soluble materials, suspended solids, high boiling compounds or high organohalide levels, it may be necessary to wash out the syringe or purging device with a detergent solution, rinse it with distilled water and then dry it out in a 105°C oven between analyses.

8.2. Purging Device Contamination

Impurities in the purge gas and from organic compounds out-gassing from the plumbing ahead of the trap account for the majority of contamination problems. Laboratory reagent blanks must be analyzed to demonstrate that the analytical system is free from contamination under the conditions of the analysis. Frequent bake-out and purging of the entire system may be required.

8.3. Sample Contamination

Samples can be contaminated by diffusion of volatile organics (particularly methylene chloride and fluorocarbons) through the septum seal of the sample vial during shipment and storage. A trip blank must be prepared from reagent water and carried through all sampling and handling protocols to serve as a check on such contamination.

8.4. Laboratory Contamination

The laboratory where volatile analysis is performed should be completely free of solvents.

9. SUGGESTED INSTRUMENT SETTINGS

9.1. Purge and Trap

- Purge Gas: Helium
- Purge Temperature: Ambient for water; 40°C for soils and other solid matrices

- Purge Gas Flow Rate: 35-40 ml per minute
- Purge Time: 10 minutes
- Desorb Temperature: 180°C
- Desorb Time: 4 minutes
- Bake Temperature: 225°C
- Bake Time: 7-10 minutes
- Preheat Time (before purging solid materials): variable, typically 1-5 minutes

9.2. Gas Chromatograph Heated Zones:

- Photoionization Detector Temperature: 200°C
- Dry Electrolytic Conductivity Detector:

Base Temperature: 200°C

Reactor Temperature: 840°C

9.3. Gas Chromatograph Operating System:

- Oven temperature Program: Hold at 40°C for 8 minutes; increase at 4°C per minute until all desired components have eluted. Do not exceed 270°C.
- Carrier Gas Flow Rate: Helium at 6-10 ml per minute
- DELCD Detector Gas Flow: Hydrogen at 30-40 ml per minute.

9.4. Integrator Parameters:

Include zero, attenuation, chart speed, peak width, threshold and area injection. These are set to give the best response and may be changed at an experienced analyst's discretion.

10. Calibration

10.1. External Standard Calibration Procedure:

- 10.1.1. For each analyte of interest, prepare calibration standards at a minimum of 5 concentration levels. One of the concentrations should be near, but above the method detection limit. The concentrations used in preparing the curve will define the working range of the instrument.
- 10.1.2. Inject each calibration standard using the technique that will be used to introduce the actual sample into the G.C. (i.e. direct injection, purge and trap, etc.). Tabulate peak area or peak height responses against the concentration or mass injected. The results can be used to prepare a calibration curve for each analyte. A response factor (RF) is then determined as follows:

$$RF = \frac{\text{conc. or mass injected}}{\text{peak area or peak height}}$$

If the percent relative standard deviation (%RSD) of the response factor for each analyte is less than or equal to 20% over the working range, then linearity is assumed and the average response factor can be used.

$$RSD = CV = 100 \times \frac{s}{\mu}$$

where: s = standard deviation
 μ = mean

NOTE: For multi-response pesticides/PCBs, use the total area of all peaks used for quantitation.

- 10.1.3. The working response factors must be verified each day or shift by analyzing one or more calibration standards. If the response for any analyte varies from the initial calibration curve by more than 15%, for drinking water and more than 25% for all other matrices, then either a new calibration curve for that analyte will be prepared or samples analyzed for that analyte will be qualified as follows:
1. Flag positive results for that compound as estimated (J) for all samples associated with the continuing calibration.
 2. Flag non-detects as estimated (UJ) for that compound with a % D of greater than 50 for all samples associated with the continuing calibration.
 3. Compute % Difference as follows:

$$\%D = \frac{RRF_i - RRF_c}{RRF_i} \times 100$$

where:

RRF_i = average relative response factor, initial calibration

RRF_c = relative response factor, continuing calibration standard

10.2. Internal Standard Calibration Procedure:

10.2.1. To use this approach, the analyst must select one or more internal standards that are similar in analytical behavior to the compounds of interest. The analyst must further demonstrate that the measurement of the internal standard is not affected by method or matrix interferences. Due to these limitations, no internal standard applicable to all samples can be suggested.

10.2.2. Prepare calibration standards at a minimum of five concentration levels for each analyte of interest by adding volumes of one or more stock standards to a volumetric flask. To each calibration standard, add a known constant amount of one or more internal standards and dilute to volume with an appropriate solvent. One of the standards should be at a concentration near, but above the method detection limit. The other concentrations should correspond to the expected range of concentrations found in real samples or should define the working range of the detector.

10.2.3. Inject each calibration standard using the technique that will be used to introduce the actual sample into the G.C. (i.e. direct injection, purge and trap, etc.). Tabulate peak area or peak height responses against the concentration or mass injected of each compound and internal standard. Calculate response factors (RF) for each compound as follows:

$$RF = (A_s C_{is}) / (A_{is} C_s)$$

Where:

A_s = Response for the analyte to be measured.

A_{is} = Response for the internal standard.

C_{is} = Concentration of the internal standard, ug/L.

C_s = Concentration of the analyte to be measured, ug/L.

If the RF value over the working range is a constant ($\leq 20\%$ RSD), the RF can be assumed to be invariant, and the average RF can be used for

calculations. Alternatively, the results can be used to plot a calibration curve of response ratios, A_s/A_{is} versus RF.

10.2.4. The working calibration curve or RF must be verified each working day by analyzing one or more calibration standards. If the response for any analyte varies from the initial calibration curve by more than 15%, (%D > 15%) for drinking water and more than 25% for all other matrices, then either a new calibration curve for that analyte will be prepared or samples analyzed for that analyte will be qualified as follows:

1. Flag positive results for that compound as estimated (J) for all samples associated with the continuing calibration.
2. Flag non-detects as estimated (UJ) for that compound with a %D of greater than 50 for all samples associated with the continuing calibration.

11. RETENTION TIME WINDOWS:

11.1.

Before establishing windows, make sure that the GC system is within optimum operating conditions. Make three injections of the multi component standard mixtures and multi-response products (i.e. PCBs) throughout the course of a 72 hour period. Serial injections over less than a 72 hour period result in retention time windows that are too tight.

11.1.1. Calculate the standard deviation of the three absolute retention times for each standard. For multi-response products chose one major peak from the envelope and calculate the standard deviation of the three retention times for that peak. The peak chosen should be fairly immune to losses due to degradation and weathering in samples.

11.1.2. Plus or minus three times the standard deviation of the absolute retention times for each standard will be used to define the retention time window; however, the experience of analyst should weigh heavily in the interpretation of chromatograms. For multi-response products (i.e. PCBs), the analyst should use the retention time window but should primarily rely on pattern recognition.

11.2. FREQUENCY

11.2.1. Retention time windows must be calculated for each standard on each GC column and whenever a new GC column is installed.

12. METHOD DETECTION LIMITS

12.1. Procedure

Method detection limits (MDLs) must be determined for each compound according to procedures specified in 40 CFR 136, Appendix B.

12.1.1. Method detection limits are compound dependent and vary with purging efficiency and concentration. The MDLs for selected analytes are presented in Table 4. The applicable range of this method is compound and instrument dependent but is approximately 0.1 $\mu\text{g/l}$ to 200 $\mu\text{g/l}$. Analytes that are efficiently purged from water will not be detected when present at low concentrations, but they can be measured with acceptable accuracy and precision when present in sufficient amounts. Determination of some structural isomers (i.e. xylenes) may be hampered by coelution.

13. GAS CHROMATOGRAPHIC ANALYSIS

13.1. Sample Introduction Technique

Introduction of organic compounds into the gas chromatograph varies depending on the volatility of the compound(s). Volatile organics are primarily introduced by purge and trap. However, there are limited applications where direct injection is acceptable. Use of the headspace technique may be valuable as a screening technique with some sample matrices to prevent overloading and contamination of the GC systems.

13.1.1. Inject 2 to 5 μL of the sample extract using the solvent flush technique. Smaller (1.0 μL) volumes can be injected if automatic devices are employed. Record the volume injected to the nearest 0.05 μL and the resulting peak size in area units or peak height

13.1.2. If responses exceed the linear range of the system, dilute the sample or sample extract and reanalyze. It is recommended that extracts be diluted so that all peaks are on scale. Overlapping peaks are not always evident when peaks are off scale. Computer reproduction of chromatograms, manipulated to ensure all peaks are on scale over a 100 fold range, are

acceptable if linearity is demonstrated. Peak height measurements are recommended over peak area integration when overlapping peaks cause errors in area integration.

- 13.1.3. If peak detection is prevented by the presence of interferences, further cleanup is required.

13.2.

Samples are analyzed in a set, referred to as an analysis sequence. The sequence begins with analyzing a reagent water blank (for determination of the presence of contamination from either the analytical system, glassware, and reagents). This is followed by instrument calibration and the analysis of samples and QC samples. The sequence ends when the entire set of samples has been injected or when qualitative and/or quantitative QC criteria are exceeded (i.e. degradation of surrogate responses or a calibration check out of limits). A typical analysis sequence is presented in Table 3.

- 13.2.1. Calibrate the system immediately prior to conducting any analyses. A midlevel standard (may be the daily calibration standard) must also be injected at intervals during an analytical sequence and at the end of the analysis sequence. The calibration factor for each analyte to be quantitated must not exceed a 15% difference (for drinking water, 25% for other matrices) when compared to the initial standard of the analysis sequence. When this criteria is exceeded, inspect the GC system to determine the cause and perform whatever maintenance is necessary before recalibrating and proceeding with sample analysis. All samples that were injected after the standard exceeding the criteria must be reinjected, if the initial analysis indicated the presence of the specific target analytes that exceeded the criteria.

- 13.2.2. Establish daily retention time windows (see section 11.0) for each analyte. Use the absolute retention time for each analyte from section 11.1.1 as the midpoint of the window for that day. The daily retention time window equals the midpoint \pm three times the standard deviation determined in section 11.1.2.

- 13.2.2.1. Validate the qualitative performance of the GC system by using midlevel standards interspersed throughout the analysis sequence (3.6) to evaluate this criterion. If any of the standards fall outside their daily retention time window (RT of the daily

standard \pm 3 s.d.), the system is out of control. Determine the cause of the problem and correct it.

13.3. System Performance Check

It may be useful to perform a system performance check before using the calibration curve by examining the average response factors for the following compounds: chloromethane, 1,1-dichloroethane, bromoform, 1,1,2,2-tetrachloroethane, and chlorobenzene. These compounds can be used to check compound instability and check for degradation caused by contaminated lines or active sites in the system.

1. Chloromethane - this compound is the most likely compound to be lost if the purge flow is too fast.
2. Bromoform - this compound is one of the compounds most likely to be purged very poorly if the purge flow is too slow. Cold spots and/or active sites in the transfer lines may adversely affect response.
3. Tetrachloroethane and 1,1-dichloroethane - these compounds are degraded by contaminated transfer lines in purge and trap systems and/or active sites in trapping materials.

14. SAMPLE PREPARATION

14.1. Water Samples

- 14.1.1. All blanks, standards, and samples must be allowed to warm to ambient temperature before analysis.
- 14.1.2. Screening of the sample prior to purge and trap analysis will provide guidance on whether sample dilution is necessary and will prevent contamination of the purge and trap system. This may be accomplished using the 3810 Headspace method.
- 14.1.3. Blanks, standards and samples (and sample dilutions) may be loaded through the sample valve using a 5 mL Luerlock syringe.
 - 14.1.3.1. To load through the valve with the Luerlock syringe, remove the plunger from the syringe barrel. Rinse the syringe with sample before injection. Carefully pour the sample into the barrel until the sample just overflows. Insert plunger and adjust to desired volume. Vent any residual air while adjusting

to volume. This process of taking an aliquot destroys the validity of the liquid sample for future analysis; therefore, if there is only one VOA vial, the analyst should fill a second syringe at this time to protect against possible loss of sample integrity. Alternatively, transfer a second aliquot of sample to a smaller vial with no headspace. This second sample is maintained only until such time when the analyst has determined that the first sample has been analyzed properly. If a second analysis is needed from a syringe, it must be analyzed within 24 hours. Care must be taken to prevent air from leaking into the syringe.

- 14.1.3.2. Surrogate standards are added to the sample in the Luerlock syringe before loading the sample into purge glassware.
- 14.1.4. The following procedure is appropriate for diluting purgeable samples. All steps must be performed without delays until the diluted sample is in a gas-tight syringe.
 - 14.1.4.1. Dilutions may be made in volumetric flasks. Select the volumetric flask that will allow for the necessary dilution. Intermediate dilutions may be necessary for extremely large dilutions. For dilution of methanol extracts, inject an appropriate aliquot of extract into the sample syringe filled with an appropriate amount of dilution water.
 - 14.1.4.2. Calculate the approximate volume of reagent water to be added to volumetric flask and add slightly less than this quantity of water to the flask.
 - 14.1.4.3. Add the proper aliquot of sample into the volumetric flask. Aliquots of less than 1 mL are not recommended. Dilute the sample to the mark with reagent water. Cap flask and invert three (3) times. Repeat procedure for additional dilutions.
 - 14.1.4.4. Fill a 5 mL Luerlock syringe with diluted sample as in step 14.1.3.
- 14.1.5. Attach the syringe to the syringe-valve assembly of the purging device. Open the syringe valves and inject sample through the valve into the purging chamber.

14.1.6. Close the valves to purging chamber and syringe, and purge sample for the times specified.

14.1.7. If the initial analysis of a sample has a concentration of analytes that exceeds the calibration, the sample must be reanalyzed at a higher dilution to obtain a response in the upper half of the calibration curve.

14.2. Water Miscible Liquids

Water miscible liquids are analyzed as water samples after first diluting them at least 50-fold with reagent water. Dilution can be prepared by transferring 2 mL of sample to a 100 mL volumetric flask and diluting to a volume with reagent water. Transfer immediately to a 5 mL gas tight syringe. Add surrogate spiking solution.

14.3. Sediment/Soil and Waste Samples

It is recommended that all samples of this type be screened prior to purge and trap GC analysis due to possible contamination of the system. This screening data may be used to determine whether to use the low level method (0.005-1 mg/kg) or the high level method (> 1 mg/kg).

14.3.1. Low Level Method: This is designed for samples containing individual purgeable compounds of < 1 mg/kg. It is limited to sediment/soil samples and waste that is of a similar consistency (granular and porous). The low-level method is based on purging a heated sediment/soil sample mixed with water containing the surrogate and, if applicable, matrix spiking standards. Analyze all blanks and standards under the same conditions.

14.3.1.1. Use a 2-5 g sample if the expected concentration is <0.1 mg/kg or a 1 g sample if the expected concentration is between 0.1 and 1 mg/kg.

14.3.1.2. The GC system should be set up according to the specifications within this method SOP. This should be done prior to the preparation of the sample to avoid loss of volatiles from standards and samples. A heated purge and trap calibration curve must be prepared and checked at least once daily for all samples analyzed using the low level method. Use a 40° C pre-purge and purge temperature for method 8021 and 85°C for method 8015. Follow the initial and daily calibration instructions in this SOP except for the addition of a 40°C purge temperature for Method 8021.

- 14.3.1.3. Remove plunger from a 5 mL Luerlock type syringe and fill until overflowing with reagent water. Replace the plunger and compress the water to vent trapped air. Adjust volume to 5 mL. Add surrogate spiking solution to the syringe through the valve. Matrix spiking solutions, if needed, should be added at this time.
- 14.3.1.4. The sample (for volatile organics) consists of the entire contents of the sample container. Do not discard any of the supernatant liquids. Mix the contents of the sample container with a narrow metal spatula. Weigh the desired amount (up to 5 g) into a tarred purging device. Note and record weight to the nearest 0.1 gram.
- 14.3.1.5. In certain cases, sample results are desired based on a dry-weight basis. When such data is desired, a portion of sample for moisture determination should be weighed out at the same time as the portion used for analytical determination. Immediately after weighing the sample for extraction, weigh 5-10g of the sample into a tarred crucible. Determine the percent moisture by drying overnight at 105°C. Allow to cool in a desiccator before weighing:

$$\%moisture = \frac{g \text{ of sample} - g \text{ of dry sample}}{g \text{ of sample}} \times 100$$

- 14.3.1.6. Add the spiked reagent water to the purge device containing the weighed amount of sample and connect device to the purge and trap system.

NOTE: Prior to the attachment of the purge device, Steps 14.3.1.4 and 14.3.1.5 must be performed rapidly and without interruption to avoid loss of volatile organics. These steps must be performed in a laboratory free of solvent fumes.

- 14.3.1.7. Heat the sample at 40°C ± 1°C (Method 8021). Use purge and trap operating parameters and analyze as stated in SOPs for 8021 and 8015 methodologies.
- 14.3.2. High Level Method This method is based on extracting the sediment/soil sample with methanol. A waste sample is either extracted or diluted, depending on its solubility in methanol. An aliquot of the extract is added

to reagent water containing the surrogate standards and, if applicable, matrix spike standards. This is purged at ambient temperatures for 8021. All samples with an expected concentration of >1.0 mg/kg should be analyzed by this method.

14.3.2.1. The sample (for volatile organics) consists of the entire contents of the sample container. Do not discard any of the supernatant liquids. Mix the contents of the sample container with a narrow metal spatula. For soil/sediment samples that are insoluble in methanol, weigh 1 to 5 g (wet weight) of sample into a tarred 12 or 20 vL vial. Note and record weight to 0.1 g and determine the percent moisture of the sample using the procedure in Step 14.3.1.5. For waste that is soluble in methanol, weigh 1 g (wet weight) or pipet 1.0 mL into a tarred vial or 10 mL volumetric flask. (If a vial or a tube is used it must be calibrated prior to use. Pipet 10.0 mL of methanol into the vial and mark the bottom of the meniscus. Discard this solvent.)

14.3.2.2. For samples insoluble in methanol, quickly add 10 mL methanol, recap and shake for two (2) minutes. For waste that is soluble in methanol, add the appropriate amount of methanol to dilute to 10 mL.

NOTE: Steps 14.3.2.1 and 14.3.2.2 must be performed rapidly and without interruption to avoid loss of volatile organics. These steps must be performed in a laboratory free from solvent fumes.

14.3.2.3. Pipet approximately 1 mL of extract to a GC vial for storage using a disposable pipet. The remainder may be disposed of. Transfer approximately 1 mL of the reagent methanol to a separate GC vial for use as a method blank for each set of samples. These extracts may be stored at 4°C in the dark prior to analysis.

14.3.2.4. The GC system should be set up according to the conditions in this method SOP. This should be done prior to the addition of the solvent extract to water.

14.3.2.5. Remove the plunger from a 5.0 mL Luerlock syringe and fill until overflowing with reagent water. Replace the plunger and compress the water to vent trapped air. Adjust the volume to 5

mL. Add surrogate spiking solution. Add appropriate aliquot of solvent extract (up to 100 uL).

14.3.2.6. Attach the syringe to the syringe valve on the purging device. Open the syringe valve and inject the water/solvent sample into purging chamber.

14.3.2.7. Proceed with analysis as specified in this SOP for Method 8021 or Method 8015. Analyze all reagent blanks on the same instrument as that used for the samples. The standards and blanks should also contain the same amount of solvent extract as in step 14.3.2.5 to simulate the sample conditions.

14.4. Bakeout Procedure

Following purge and trap analysis, rinse needles with R/O water, purge each sparge chamber for at least 30 seconds, and bake the trap for a 10 minute cycle. Clean all glassware appropriately.

15. CALCULATIONS

15.1. External Standard Calibrations

The concentration of each analyte in the sample may be determined from the peak response (area or height) and using the response factors from the calibration curve as follows:

For Aqueous Samples:

$$\text{Concentration}(\mu\text{g} / \text{L}) = \frac{(A_x)(A)(V_i)(D)}{(A_s)(V_i)(V_s)}$$

Where:

A_x = Response of the analyte in the sample (peak area or peak height)

A = Amount of standard injected or purged (ng).

A_s = Response for the external standard, same units as A_x .

V_i = Volume of extract injected, uL. Not applicable for purge and trap, $\therefore = 1$.

D = Dilution factor, if dilution was made on the sample prior to analysis.

V_i = Volume of total extract, Not applicable for purge and trap analysis, $\therefore = 1$.

V_s = Volume of sample extracted or purged, mL.

Non-Aqueous Samples:

$$\text{Concentration}(\mu\text{g} / \text{kg}) = \frac{(A_x)(A)(V_i)(D)}{(A_s)(V_i)(W)}$$

Where:

A_x = Response of the analyte in the sample (peak area or peak height)

A = Amount of standard injected or purged (ng).

A_s = Response for the external standard, same units as A_x .

V_i = Volume of extract injected, uL. Not applicable for purge and trap, $\therefore = 1$.

D = Dilution factor, if dilution was made on the sample prior to analysis.

V_t = Volume of total extract, Not applicable for purge and trap analysis, $\therefore = 1$.

W = Weight of sample extracted or purged, kg. The wet weight or dry weight may be used, depending upon the specific applications of the data.

15.2. Internal Standard Calibrations

For each analyte of interest, the concentration of that analyte in the sample is calculated as follows: Aqueous Samples:

$$\text{Concentration}(\mu\text{g} / \text{L}) = \frac{(A_x)(C_{is})(D)}{(A_{is})(RF)(V_s)}$$

Where:

A_x = Response of the analyte being measured, units may be in area counts or peak height.

C_{is} = Amount of internal standard added to extract or volume purged, ng.

D = Dilution factor, if a dilution was made on the sample prior to analysis. If no dilution was made, $D=1$, dimensionless.

A_{is} = Response of the internal standard, units same as A_x .

RF = Response factor for analyte, as determined in Step 6.4.3.3.

V_s = Volume of water extracted or purged, mL.

Non-Aqueous Samples:

$$\text{Concentration}(\mu\text{g} / \text{kg}) = \frac{(A_x)(C_{is})(D)}{(A_{is})(RF)(W_s)}$$

Where:

A_x = Response of the analyte being measured, units may be in area counts or peak height.

C_{is} = Amount of internal standard added to extract or volume purged, ng.

D = Dilution factor, if a dilution was made on the sample prior to analysis. If no dilution was made, $D=1$, dimensionless.

A_{is} = Response of the internal standard, units same as A_x .

RF = Response factor for analyte, as determined in Step 6.4.3.3.

W_s = Weight of sample extracted, g. Either a dry weight or wet weight may be used, depending upon the specific application of the data.

16. Quality Control

16.1. Instrument Blanks

Each 24-hour day must begin with an instrument blank to verify that the purge and trap/GC system is not contaminated. The instrument blank also serves as a "dry run" to condition the system for testing of the reagent blank.

16.2. Reagent Blanks:

The purge and trap grade water with the surrogate/internal standard spiking solution added is analyzed to verify that the reagent water is free of contamination.

16.3. Method Blanks

The analytical system may be further demonstrated to be free from contamination under the conditions of the analysis by testing a method blank each day. Method blanks consist of an aliquot of purge and trap water, surrogate/internal standard spiking solution and five grams of EPA approved blank soil matrix.

16.4. Laboratory Control Sample

The validity of the method and instrument operation are to be verified by the analysis of a laboratory control sample (LCS) once at the beginning of each 24-hour testing day. The method is considered to be operating in a valid manner if all target analytes are within 70 to 130 percent recovery or within the advisory limits specified by the EPA or certified vendor.

16.5. Matrix Spike/Matrix Spike Duplicates (MS/MDS)

At least one set of MS/MSD samples must be analyzed for each 20 samples of the same matrix to acquire data for measurement of accuracy and precision. The percent recoveries are compared with the acceptance criteria given in Table 2. If one of the target analytes exceeds the acceptance criteria, a continuing calibration check sample must be analyzed to check instrument calibration. If continuing calibration criteria are not achieved for the parameters that failed the limits for spike recovery, the affected samples must be reanalyzed using a new calibration curve. If continuing calibration criteria are met, the poor recoveries can be attributed to matrix effect.

16.6. Surrogates

All samples, standards and blanks (except instrument blanks) must be spiked with surrogate compounds prior to purging. Data for the surrogates for all analyses must be tabulated and routinely processed statistically for determination of warning and control limits. The control limits for the surrogates are considered to be ± 3 standard deviations from the mean. If a surrogate exceeds the control limits, the sample must be reanalyzed. If the surrogate recoveries are still more than 3 standard deviations from the mean after reanalysis, then the sample results must be reported with a qualifying statement that the data is suspect due to matrix effects.

16.7. Trip Blanks

A trip blank is an aliquot of deionized, analyte free water that is sealed in a 40 ml VOA vial and acidified with 1N HCl to a pH of less than 2. Trip blanks are placed in a cooler and accompany field personnel during sampling activities. One trip blank per cooler is to be analyzed by the laboratory.

16.8. Equipment/Field Blanks

A field blank is an aliquot of deionized, analyte free water which has been supplied by the laboratory and used to rinse the field sampling equipment after decontamination. A field blank is taken for each media sampled (i.e. for each type of sampling device) at a frequency of one field blank per sampling day per media. In this manner, any possible cross-contamination accruing among samples due to the repeated use of the same sampling equipment can be assessed. The field blank must accompany the samples that are taken that day.

16.9. Field Duplicates

Field duplicate samples are two separate samples taken from the same sampling point in the field (i.e., in separate containers and analyzed independently). Evaluation of duplicate data can indicate the existence of gross errors in the sampling technique. One field duplicate per analytical batch per matrix or every 20 samples, whichever is greater is to be analyzed by the laboratory.